ELEMENTARY SCHOOL AGRICULTURE

A TEACHER'S MANUAL

TO ACCOMPANY HILGARD AND OSTERHOUT'S "AGRICULTURE FOR SCHOOLS OF THE PACIFIC SLOPE"

BY

ERNEST B. BABCOCK

AND

CYRIL A. STEBBINS

New York

THE MACMILLAN COMPANY

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C. A. Stebbins

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INTRODUCTION

It is the purpose of this little manual to help the ambitious teacher, who is not afraid of work, to begin the teaching of Agriculture. The writers believe that agriculture should be introduced in all elementary schools, but in making this statement it seems necessary to explain briefly what we mean by Elementary School Agriculture and how we think it should be introduced.

Agriculture, in the mind of the careless thinker, is sometimes synonymous with farming. Now farming is a noble and, fortunately, an increasingly attractive occupation, but the term Agriculture has a vastly bigger content than the term farming. Agriculture is both a science and an art. It is, in fact, a great composite of the fundamental sciences and, during the progress of civilization, has come to include a long list of elementary arts and technical industries. Even in the high school we find only a few of the fundamental sciences that go to make up the great science of Agriculture and fewer still of the elementary arts. Far be it from the elementary school to teach science *as such*. There is less danger of this than ever before. The mission of nature study has been fulfilled in part. It is now generally believed that natural history as a school subject can be made a powerful educative agent. On the other hand, the manual arts employed in Agriculture comprise a most valuable sort of practical training for the young.

" Agriculture on its practical side contains a large fund of material well adapted for teaching purposes to those untrained in the sciences underlying its various operations. Right modes of planting may be taught without much reference to why some seeds are placed deeper than others. Good tillage can be taught, even though the laws of capillarity, soil temperature, and the like are not understood. Legumes may be grown and plowed under and other modes of soil enrichment may be practiced without much knowledge of bacteria

or of the chemistry of fertilizers or of plant physiology. Seed selection may be carried on quite extensively with little or no knowledge of the laws of heredity. Feeding one ration to obtain milk and another to produce flesh need not involve much knowledge of the physiology of assimilation or of the chemistry of digestion. Spraying for insects and fungi as a protective measure need not imply an extensive knowledge of entomology or cryptogamic botany. Grafting, budding, and other forms of propagation need not rest on a very broad knowledge of plant anatomy and physiology.

"Learning to do the things in the foregoing summary has some very decided educational values. One of its values lies in the fact that it stores the mind with a fund of experimental knowledge. This makes it vital to one's thinking. It is also valuable as a stimulant to the inquisitive mind looking for the real reasons why things transpire as they do. It is further valuable as affording a reservoir of material for example or illustration to one in pursuit of a law or principle in the natural world."[1]

Now, if *learning to do* these things — the mastery of the elemental arts of agriculture — is valuable in itself, how much more valuable must such practical training become if it is preceded or accompanied by proper instruction regarding those natural phenomena and laws upon which such practice actually depends! This is one function of nature-study. Even in the primary grades pupils may extend their acquaintance with natural objects and phenomena in such a way that when they come to agriculture as a grammar school subject they will have a background of experience which is such an advantage to any one who studies this subject. For this reason we urge the strengthening of nature-study, including gardening in the primary grades as a preliminary step, if possible, to the introduction of agriculture in the grammar grades.[2]

But many communities desire that Agriculture be introduced

[1] "The Place and Function of Agriculture in the Curriculum," W. R. Hart, Nature Study Review, vol. 5, no. 6, Sept. 1909, p. 163.

[2] See "General Plan for Organization of the Nature or 'Science' Teaching in Elementary Schools," E. B. Babcock, Sierra Educational News, Vol. VI, no. 1, pp. 49, 50.

into the grammar grades immediately and many county boards of education are sanctioning such a step by the recognition of some particular textbook on Agriculture. In districts where the step is taken without previous warning, grammar grade teachers find themselves confronted by difficult problems. The question arises at once, How shall I begin? It is certain that to begin with the mere reading of a text, no matter how excellent, will not provide the practice work — the doing element — which is so desirable. The vitality of agriculture in the common school will be found in the school garden and in the class room experiments. The skillful teacher will continually stimulate the activities of the pupils in the direction of original experimentation, bringing them to meet problem after problem. The common measure of man's power is his ability to handle new situations. The pupil who has answered by himself a problem question in a satisfactory manner has added much toward character building. Many such experiences give the power which is necessary to make one a force in one's community.

Another means for awakening interest in boys and girls is the organization of school agriculture or gardening clubs. This may be either a local affair or affiliation may be arranged with a general movement such as the Junior Gardening Clubs now being organized by the College of Agriculture at Berkeley. Information regarding this movement will be sent upon application.

The success of all these *activities* in public school Agriculture depends largely upon the enthusiasm and resourcefulness of the teacher. But, in the beginning of new work, definite suggestions are often invaluable. It is the aim of this manual to give such suggestions, first, for the school garden, second, for schoolroom experiments supposed to lead up to and accompany the garden and the textbook work.

Notebooks are helpful in the higher grades if they are used as means to an end and do not become notebooks for the sake of notebooks. A notebook is potential, just as is a textbook, in the direction of squeezing the vitality out of a teacher and out of the pupil and out of the subject. The common measure for a teacher is his perspective, the depth of his point of view. Too often the school

exists for the school's sake, the course of study is compiled for the sake of the course of study, and the pupil is marched through it rather than the course of study marched through the pupil. The teacher too often teaches the child for its own sake rather than for the sake of the child's usefulness to its neighbors and the world. Further, he is liable to see in this new call for Agriculture nothing but Agriculture, and not its value as a means to an end, the end being, (1) to create a sympathy for farming, for country life; (2) to readjust the individual to his community living; (3) to give new direction to the old subjects in the curriculum.

Therefore, let us make elementary school agriculture stand for something more than manual art, something more than nature-study. Let us use it as a means for adjustment to the needs of a progressive civilization, in which true culture is not considered as a vague ideal, but an intelligence that expresses itself in real service to humanity.

School Gardens

Children, inclosed by the walls of the schoolroom and imprisoned in spaces bounded by the desks, are much like fish in a glass bowl. The space in the case of the fish admits of limited movements and unnatural living. The necessary amount of oxygen and nutriment derived from the vigorous natural living and the activity caused by life bubbling over is denied the captive. Individual retrogression, followed by fungus diseases and death, is the usual result for the fish. To the boys and girls the desks admit of slight stretching and an aggravating amount of twisting and turning, as any teacher will testify. This is a poor substitute indeed for that which the system demands. In twists and turns Nature rebels against inactivity.

The present school life needs something too large or too active to be brought into the schoolroom, something which will make the boys and girls immune from the attacks of the schoolroom fungus which fills them with the mycelium of dislike for the school, which makes books and desks their memory focus, and which finally drives them from the influence of the school. While window boxes and aquaria have their reasons for being, we are glad that teachers can

bring neither school gardens nor creeks into the schoolroom. We sometimes forget that the schoolhouse with its apparatus is made for the children, not the children for the schoolhouse.

The baby with its amazing contortions and physical reactions demonstrates beyond a doubt the rapid development of the motor centers as compared with the sense centers. The school should offer something more than recesses to meet this fact, particularly in the lower grades. The flow of motor impulses can only be checked for a short time, so it necessitates direction of, rather than attempts for suppression of, these impulses. Rather than to try to suppress the physical bubbling over expressed in running, etc., let us direct the run, the jump, and the kick.

School gardens offer the easiest solution of the problem of direction since they use and use well the surplus energy. To observe a hundred children at work in the gardens, spading, hoeing, raking, from the viewpoint of the enormous amount of energy expended, one stands fully convinced of the unnaturalness of long study and recitation periods, and realizes the responsibility of teachers in directing and controlling the energy. They need assistance from the course of study. For a short time skillful teachers may keep energetic classes inactive yet full of attention, but gradually the flow of bodily energy, dammed up as it were, trickles out in mischief. It is not strange that after Nature has been giving satisfaction to the motor impulses of the children in the gardens, they go back to the schoolroom reluctantly yet physiologically better prepared for inside work.

Does not the problem of discipline resolve itself into a problem of proper oxidation and the direction of the resultant energy? A bad boy is the result of misdirected energy. Something blighted his natural development. Fasten his energies to a spade and the "badness" seems to dispel itself in the ground. Can we not use the hint given us by this experience with many misunderstood boys?

In a course of nature-study, the gardens furnish the center from which radiate many and various interests inorganic and organic in nature.

Continuity, not isolation of subject matter, is essential. The potency of the school garden as a unifying element in the school work is very great and is illustrated by the diagram. Children in the garden see insects, other animals, and the effects of various natural forces, and are thus naturally introduced into new fields. Not only are these factors now closely related to the lives of the children, but the school itself may be linked to life. The old subjects in the

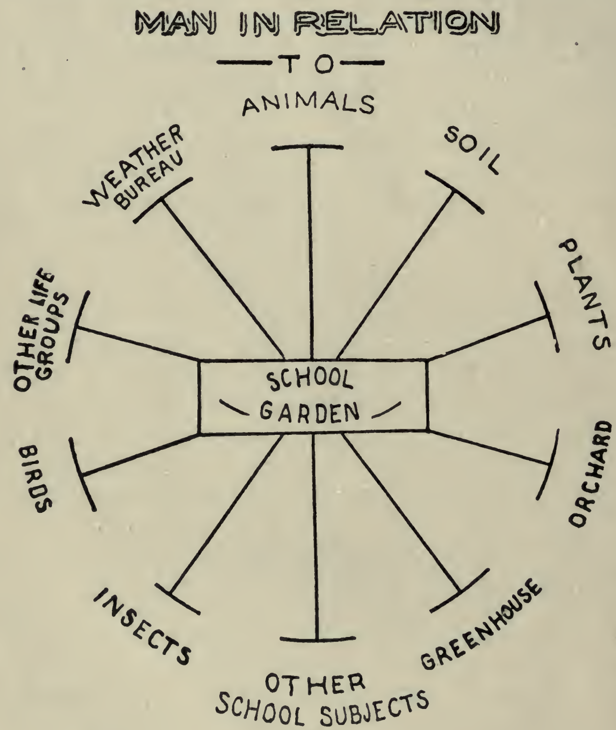


FIG. 1.

curriculum may be given new direction. The criticism on the present school system should not rest so much upon the subjects taught

as upon the direction of these subjects. With gardens under way the problem in arithmetic may be one grown out of the children's activities in the garden, instead of one devised by the teacher and one far removed from the children's interests. This illustration (Fig. 1) will suffice to point out one large aim of the school garden — to readjust school work to life work.

The garden carries a world with it, patterned after the universe. It is potential in the direction of an embryo community in which the children are brought in contact with those factors and those forces which make for real community life. The life of the present generation is growing so very complex that it demands of the coming generation high specialization in many lines. Specialization caused by competition tends to emphasize economic life. The school garden will flourish, if for no other reason, so long as the world kneels to money, for the proper handling of soil and seeds which represent the stored energy of Nature, the control of insect pests, the prevention of fungous diseases, all culminate in the perfect fruit, a product of man's energy, both mental and physical, standing for dollars and cents.

More and more are we brought to see that the present complex life calls for the individual with a broad social perspective. The gardens offer opportunities in forming correct social views and habits early in life. In modern schools many children, many individual gardens, community gardens, public paths, public tools, public water, and many other relations both public and private, make a social life no less complex and difficult to handle than that of a city. Early in their garden life, the children are taught to respect those things which belong to their neighbors; to realize that community property belongs to the whole not to a part, and that each must offer his support; to understand that the policy which is best for the majority must be supported; to see the justice in ten of a class insisting that the eleventh remove objectionable weeds from his garden, or the justice of eminent domain; to feel, in general, that each represents but one small part of a great whole and that each must do his best to fit in smoothly and laugh with the world rather than to be shoved aside to cry alone.

Habits of care formed through continual attention to clean tools, etc., will lessen the friction of the children's lives.

Continual attention to seeding, growing, spraying, harvesting, will prevent some of the waste characteristic to California.

The complexity of our national life is brought about by man's power to absorb and interpret his experiences and by his ability to apply these experiences in his own conduct. By means of school gardens pupils gain experiences which help them to interpret natural forces and which develop the power to apply these forces in their own conduct.

From the viewpoint of pleasure alone the school garden has its reason for being. If red cheeks, bright eyes, abounding joy and interest are indicative, the garden work is worth while as a pleasure-giver. Many a tired, patient housewife has drawn from her little garden in the backyard comfort and rest, and has been rejuvenated thereby. The soil and plant life are ever suggestive of vitality, courage, and peace. But there are too few home gardens and too many empty cans in the backyard. Shall we not inoculate the boys and girls with the garden spirit which makes for vigorous manhood and womanhood and which is so potential for joy?

While it is to be lamented, it is none the less true, that for many years "farmer," in the public mind, has stood for an uneducated, ungainly, uninteresting human being clad in overalls, an unattractive future to any boy, influenced by a biased people. We want the school gardens to get a chance at the boys and girls before a prejudiced influence reaches them. We want them to see that the schools, the universities, and the world are getting behind the farmer; to feel that it is an honor, rather than a disgrace, to be a countryman; to see that the world has demanded farmers with the same breath that it has ridiculed them; all to create a sentiment, productive in sympathy for farmers and farm life.

The Garden Plot

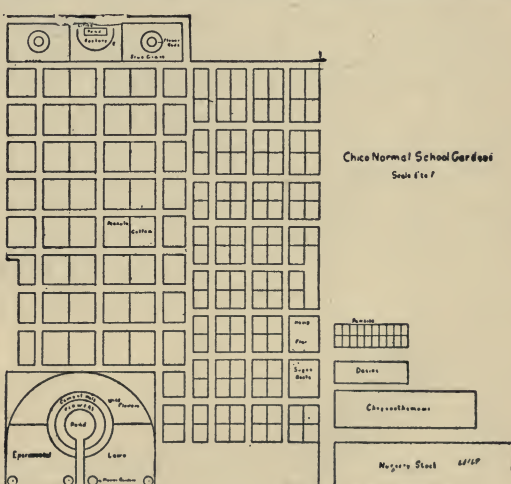
Select a well drained sunny plot which can be easily fenced if necessary. If possible, lay out the plot with a wind break on the north.

Size of Plot. — Determine the size of the plot by (1) the number of pupils to undertake the work, (2) the size of the individual gardens, (3) the amount of energy to be expended.

We believe in school gardens for all classes. However, it is best to start in a limited way with one or two grades. The fifth and sixth grades take up the study very readily.

Individual gardens 3 × 5 feet for the low classes and 6 × 8 feet for the high grades make convenient sizes. Give each pupil an individual plot and select one for yourself, for you need a garden. Arrange for an experimental garden and a community plot for each grade or group. Each group should have an experiment under way.

The Plan. — With data in hand assist the children to plan and make a drawing of the gardens. Bear in mind ease of access to each garden from three sides, as well as the general appearance of the garden as a whole. Assign the gardens, marking each garden on the plan. A model plan is shown in the accompanying diagram.



Preparation of Plots. — If the plot is of considerable size, have it plowed and harrowed; otherwise have the children spade the plot. Do not kill the interest with too much drudgery. We observed three boys working up an acre of ground with a hand plow. It was fun the first day, work the next, drudgery the next, and the final result was loss of interest. The plot was never seeded.

Laying out of Garden. — Ask the children to bring tools to the school. Have the boys make stakes, three to each pupil, fourteen inches long, $1\frac{1}{4} \times 1\frac{1}{4}$ inches, sharpened at one end. These should be painted white. With a tape measure, yard sticks, stones or mallets, two or three balls of string, and a plan, you are ready to lay out the gardens. Half a dozen boys with work planned for each can lay out a plot a half acre in size in one hour by using the following method. Let two boys measure and mark off the four corners. Direct one boy to follow carrying stakes, another accompanying him to drive the same. Have one boy carry string. Have the string stretched around the four corner stakes. Let boys with yard sticks measure off distances according to the plan and mark the places for stakes on two sides. Caution the boys to see that the stakes are always driven on the same side of the string. Let boys with mallets and stakes follow, driving the stakes carefully in their proper places. With the stakes driven on opposite sides direct others to stretch string across connecting the corresponding stakes. The string need not be broken at each stake. It may be merely wound and carried on to the next stake. With stakes driven at their respective distances at the two remaining sides, treat as above with the string. The garden now has the appearance of a great cobweb with the string crossing in such a way as to outline each garden. The whole class may now be used to drive stakes at each intersection of the string. Use great care to have the stakes driven perpendicularly and on the correct side of the string. With the stakes in place unwind the string. Do not let the string remain. It stretches and is easily broken. Instruct the children to level the paths and to lower them two inches. Thus the plots are slightly raised, giving an attractive appearance to the gardens and making drainage more ideal.

If possible let the children begin at once to spade up the soil. With the soil carefully cultivated the gardens are ready for seeding. Teach the children the "trench" method in spading. Demonstrate in your own garden at the proper time (1) how to spade, (2) how to fine the seed bed, (3) how to plant seeds, (4) how to cultivate, (5) how to thin out. For detailed suggestions on these

points consult Bailey's "Manual of Gardening," Hall's "The Garden Yard" or other practical treatises. See Appendix C.

Select seeds that are quick hardy growers, — radishes, lettuce, peas, beets, etc., particularly if the planting season is at hand and short as to growing time. Community plots may be devoted to mass flower effect, to miniature parks, to economic plants, etc.

A teacher while proudly showing visitors the school gardens well under way was asked what was to be done with the productions. She did not know. Do not start the gardens unless a definite aim is in view. The products may be used as follows; (1) to market the vegetables and flowers, (2) for home use, (3) for seed, (4) for vegetable dinners, (5) for the school lunch table, (6) for flower and vegetable shows, (7) for a Thanksgiving gift to the needy in the vicinity.

Start economic plants such as sugar beets, flax, wheat, castor beans, pop corn, etc. These crops may be harvested in the fall term. They not only point to the work of the world, but the children do some of the work. It is a short step from the fiber in the flax plant to the world's method in clothing its people.

To harvest the sugar beets, take up the beets, cut off the tops about one inch below the leaves, and shred the roots with graters. Put this shredded material into a clean cloth bag and press out the juice. To prevent fermentation and for purposes of purification, stir a small amount of lime into the liquid. After making carbon dioxide (dilute hydrochloric acid and chalk in a bottle fitted with a tight cork and bent glass tube) pass it through the juice, causing impurities to settle. Siphon the pure juice into another dish, filter and boil for several hours. The resulting sirup cannot be refined to obtain sugar crystals but the children may profit by the lesson. If possible visit a sugar factory and make a comparison of the class process and the business man's process. Study the method of the world in furnishing sugar to its people.

To harvest the flax, pull the flax plants up by the roots, remove the seeds and leaves, place the flax plants under water for three to six days. If, at the end of this period, the stems break readily and the fiber seems to be loose, place the plants in the sun to dry.

After drying break the woody matter. With a comb, made by driving nails through a piece of wood, comb out the fiber. Weave the fiber into cloth. Study the method of the world to clothe its people.

With the gardens seeded after completion of lessons I and II the regular lessons may be taken up to be interrupted for attention to the young plants as it is needed. In a few days many plants will need thinning out and cultivation will be necessary. Demonstrate in your own garden thinning and cultivation, bringing out by questioning the reasons for each step, then direct the children to their own plots. Ere this the children will have met many factors at work in their gardens. These will suggest new fields of study, insects, birds, the weather, etc. Study these factors as the children meet them. See lessons IV to XI inclusive.

Type Lessons

As suggested before, the garden is a little world of its own, patterned after the universe. Nearly all of the factors which constitute one's environment are found at work in the school garden. When the children meet these new factors the special representation should become the type to study. If the larvæ of the cabbage butterfly are destroying the cabbages, or the grasshoppers are attacking the garden plants, take one as a type and let it introduce the children to the large field of insect life.

After the "type" has received careful attention compare other animals (if the type be an animal) to it. Keep close to type studies.

Suggestive Lessons

The following series of lessons have been successfully used in elementary school classes. They have served to prepare pupils for successful gardening and to introduce the study of Agriculture.

Have each lesson summarized, and fill in subject matter as a need is felt. Let each experiment direct conduct. Continually ask yourself this question: "How will this work direct conduct?"

In each experiment and each study that is taken up, look beyond

the matter directly at hand. See more than the individual study. Examine it to see how it is a part of the unity of nature.

Emphasize individual work. Each child should be given a specific problem. When differences arise, let the children devise an experiment. Encourage experimental study at home.

By all means perform the experiments. They take a little extra time, but the results are worth it. Showing, not telling, is the keynote in proper teaching.

Lesson I is suggestive for the use of Chapters III, IV, and part of V in "Agriculture for Schools of the Pacific Slope," Hilgard and Osterhout. In this lesson, as in others, to follow the writers' aim is to give such material as will direct conduct in the growing of plants in the school garden.

Lesson 2 directs the application of Chapters I, II, and part of V.

Lesson 3 recapitulates the work of the first two lessons in part.

Lessons 4 and 5 help in the use of Chapter I.

Lesson 6 deals with parts of Chapters IV, V, and part of XII, relative to the work of stems and roots.

Lesson 7 suggests the use of Chapters VI and VII.

Lesson 8 helps to introduce Chapter VIII.

Lesson 9 suggests the use of Chapters XV and XVI.

Lesson 10 suggests a method for the application of Chapter XVIII.

Lesson 11 will aid in presenting Chapter XIII.

These lessons are only suggestive as to the use of the text. It should be used to supplement the lessons.

The length of time given to each lesson should be determined (1) by the value of the subject matter in directing conduct, (2) by the interest of the class.

The lessons may be used in any grade from the 5th to the 8th inclusive. We have found it best to begin agriculture in the 5th or 6th grade.

LESSON I

THE SOIL

Unit of Instruction. — The soil.

General Topic Aim. — To interest the children in soil, to teach the relation existing between soil and themselves.

Specific Lesson Aim. — To teach the composition of the soil, the characteristics of clay, sand, and humus, and the relation of water to each.

Children's Aim. — To learn more about soil, since life depends upon it.

There are two ways of introducing new subject matter to children: (1) formally, — "Children, this morning we are going to study the cabbage butterfly;" (2) by making the children feel the need of the new subject. There may be points of interest in the study of the cabbage butterfly, but how much more vital to the child is knowledge of this insect if it has attacked the cabbage plants in the child's garden and he realizes that it is a question of spoiled cabbages or the death of the pest. In the one case the interest is superficial, in the other it is vital.

The first step in *any* lesson is to make the children feel the need of the work at hand. Develop in the minds of the children the value of agricultural and soil study by leading them to see the relation of the soil to their own living, that without soil there could be no homes, no food nor life of any kind. Ask them where the glass in the window came from, the source of their clothing, food, etc., leading the children to see that the real source is the soil. From the soil radiate the factors which constitute our environment. (Fig. 2.)

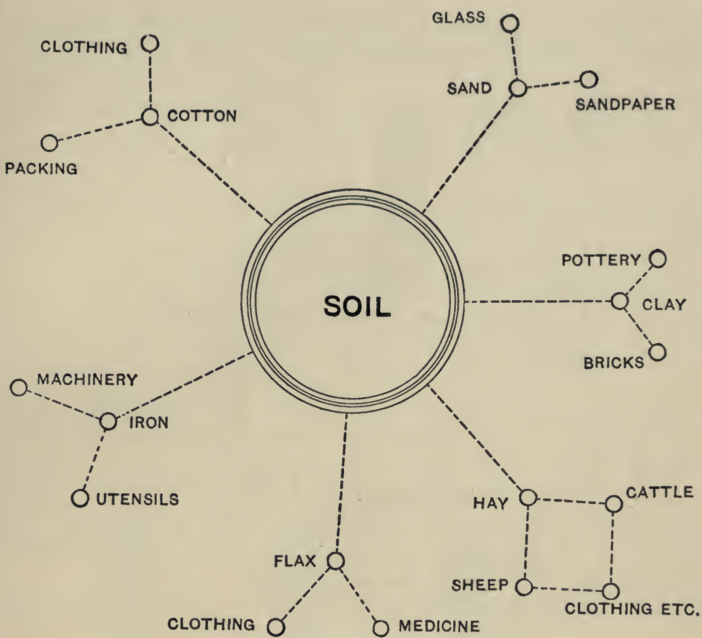


Fig. 2.

Development of Lesson

Soil is composed of clay, sand, humus. In test tubes or small dishes of any kind give the children individual samples of clay and sand.

Sand has Coarse Texture, Clay has Fine. — Class examine these samples and tell me the names for each. Now look closely so that you may answer the following questions: (1) in which are the particles larger? (2) in which do they roll about more easily? Would you rather plow sand or clay? Why? Let me draw a picture of sand and clay particles. (Fig. 3.)

The brick chimney is built by piling one brick upon another. If we should pile sand particles one upon another, what would

we build? "Funnels." The same would happen with clay particles. Would you like to know the name of these funnels in soil? Capillary tubes. In which are the tubes larger?

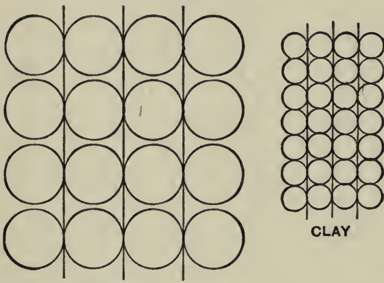


Fig. 3.

Color of Sand, Clay. — Notice the shining sand particles; what color do they give to the sand? What is the color of the clay?

The characteristics of humus resemble more nearly those of clay than those of sand. (Pass out samples of soil containing humus.) What do you find in this soil not found in the other samples? What does it look like?

(With a flame of some kind heat the humus in a tin until it smoulders.) Where have you noticed this odor before? What is humus? I found this humus beneath a tree. Where did the vegetable matter come from? Name other sources of humus.

Humus and Clay are Cold. Sand is Warm. — (Fill three cans with

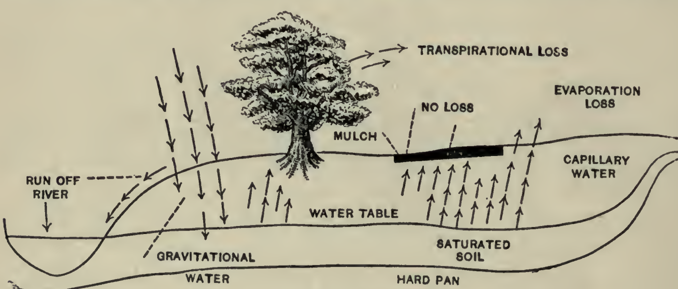


Fig. 4.

humus, clay, and sand; put a thermometer in each to determine the temperature.) Sand is too warm, clay and humus are too cold; what shall we do? "Mix sand and clay." How can we find out

whether John is right? "Experiment." Yes, to prove a theory one must experiment. (Have children see that one experiment alone may not furnish proof.)

Place in a medium-sized bottle a small amount of humus, sand, and clay. Add water till the bottle is nearly filled. Shake well and set aside.

Relation of Sand, Humus, and Clay to Water. — (Develop the great work of water in the environment of man. Put the drawing upon the board. (Fig. 4.) How does the water get to soil naturally? Artificially? By the way, is it better to sprinkle or irrigate? How shall we find out? Yes, by experimenting. This we shall do later. (Create questions to be answered by experimentation.)

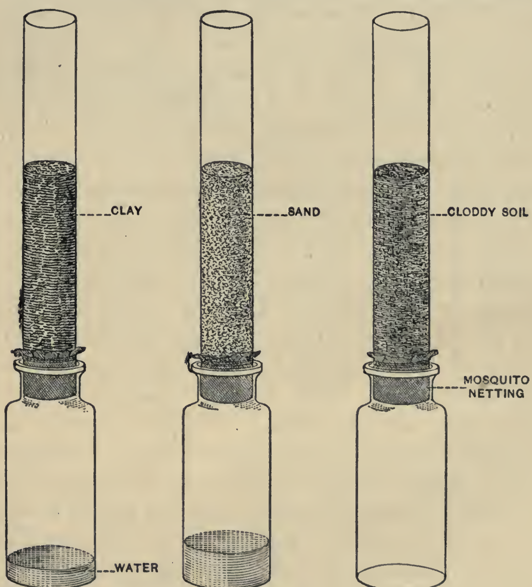


Fig. 5.

Gravitational Water Moves Rapidly in Sand and Cloddy Soil, Slow in Humus and Clay. — I have three glass tubes, one filled with sand,

one with clay, and one with cloddy soil, as shown in Fig. 5. The material is held, as you will notice, with cloth tied over the bottoms. I am going to pour the same amount of water into each. In which do you think the water will get through first? Why in the sand, Mary? "Because the particles are larger and the tubes are larger." How many agree? Since we all agree, is there any need of trying the experiment? Why? Yes, to prove Mary's theory. (Pour the water into the tubes.) The sand wins. (When children disagree as to their ideas, let each choose his tube and imagine a race.) Gravitational water carries food to the plant from the surface soil on its way down. Why is it called gravitational water?

Gravitational Water may be Conserved by Loosening the Top Soil, by Growing Plants, by Contour Plowing, by Cultivating the Seed Bed. — We have found gravitational water to run quickly through sand and cloddy soil. What do these experiments teach us about conserving gravitational water? Let us be particular in ridding the seed bed of clods when we start the gardens.

Trees and Undergrowth Prevent Run-off. — What becomes of the water that strikes the side of a hill? Yes, it is called the run-off. The run-off causes floods. What happens each year along the Sacramento River during a wet winter? What causes these floods? How can the run-off be prevented? Yes, each tree has a mass of roots, each tree is like a tub, and keeps the water from being lost. (Enlarge on the value of forestry. See Chapter 23 in text.) Contour plowing also prevents the run-off.

Capillary Water Climbs High in Clay. — Empty the glass tubes, keep the wet earth and set aside. Mix into balls sand and clay, sand and humus, clay and humus; moisten and set aside for the next lesson. Fill the tubes with dry sand, clay, and cloddy soil. Stand in a basin of water. (See Figs. 20, 21, pages 45 and 46 in text.) In which will the water climb up the highest? (Children seldom formulate a correct theory.) In a tumbler place different sizes of glass tubes, ranging from very fine (capillary) tubes to a large tube. Fill the tumbler with colored water. (To make capillary tubes, heat glass tubing in a flame. When it softens draw from the flame and quickly pull the glass to the desired diameter. Hold the tube at each

end and keep it turning while in the heat.) In which tube does the water climb the highest? Now who can tell in which cylinder the water will climb the highest? Why in the clay?

(In short tubes the water will climb most rapidly in the sand. This gives the teacher a chance to point out the value of many experiments to prove a theory. If tubes twelve to twenty-four inches in length are used, the capillary water reaches the top in the clay most quickly.) Observe that the water climbs very slowly in the cloddy soil. It is the water which climbs back that the plants need. Who knows another reason for making the seed bed fine?

The Mulch. — If I break this small tube about halfway down, what might happen, Fred? How can we stop the overflow? "Plug with cotton." If the soil is filled with these minute capillary tubes, what is the water doing? On clear days how can we prevent the overflow? Why can't we see the water as it comes out? But how can we plug the tubes? "With dirt." Yes, by making a fine mulch with harrows or hoes. Let us remember how to conserve this moisture after we start the gardens. (Develop value of dry farming. See Widtsoe's "Dry Farming," The Macmillan Co.)

Humus and Clay Hold Water Best. Sand Loses Water Rapidly. — (After the capillary action in the three tubes of earth is complete, weigh each, and from day to day weigh again to determine which kind retains water best, or arrange as in Fig. 5. The amount of water in the bottles shows relative loss of gravitational water or retaining power of sand, humus, and clay. Put the same amount of sand, clay, and humus in separate boxes. Weigh each. Add the same amount of water by weight to each. Weigh each day.) What kind of earth loses capillary water most rapidly? (Draw attention to the rains in the desert. Point out how the cactus is adapted to getting water quickly and how the modified stems store water.)

Sand with a Clayey Bed Conserves Water. — Since sand does not hold water readily and clay does, which ranch would you rather purchase, one with a sandy bed several feet below the surface or one with a clay bed? Why the one with a clay bed, James? "Moisture would be held from seeping away, while it would escape

through the sand." How might the land be tested? By using a post auger one might bore and determine the kind of base. If water is convenient for irrigating, a sandy base is not bad. For the growing of trees a deep, uniform soil is best.

(Place a portion of a plant through a cardboard fitted to the top of a tumbler so that the stem reaches water. Invert another tumbler over the plant and set aside for the next lesson. This is to illustrate loss of moisture through transpiration and will suggest the treatment of weed growth in the gardens.)

LESSON II

THE SOIL AND THE SEED

Review the lesson on the soil, emphasizing those things that will direct conduct in the gardens,—how to test the soil in the garden, how to improve the same, how to conserve moisture, the harmfulness and value of a sandy and a clayey subsoil, how to test for the same, etc.

Examine the bottle of soil and water left over from the previous lesson. The relative weight and percentages of humus, clay, and sand are indexed. Point out that valley farms are best because the water carries the light particles to the lowland. The larger particles are deposited in and near the foothills. Classify soils according to the percentage of coarse and fine sand in each.

80–100 % sand means sandy soil
60– 80 % sand means sandy loam
40– 60 % sand means loam
20– 40 % sand means clayey loam
0– 20 % sand means clay

If the time permits, point out the action of fire, water, air, plants, and animals in making soil.

Examine the dry balls of sand, clay, humus, and the mixtures prepared at the previous lesson. Clay soil bakes and puddles. Addition of sand or humus prevents this. Sand is too loose in

texture. Humus and clay give improvement. Make up an ideal soil.

New Work

General Topic Aim. — To interest the pupils in plant life through a study of the seed; to point out the relationship existing between seeds and the life of the pupils; to let the seed offer its small bit to build up a large perspective of the pupils' environment and to aid in forming the individual's philosophy.

Specific Lesson Aim. — To teach such fundamental principles regarding seeds as will direct the pupils' conduct in the school garden; namely, (1) what is a seed? (2) how deep shall a seed be planted? (3) how far apart to plant seeds, etc.

Method of Approach. — Put several Windsor (or Lima) beans to soak several days before the lesson.

The Lesson

How deep would you plant wheat? What a variety of answers you have; they vary in suggestions as to depth from one half inch to two feet. At S—— I gave the pupils some Acacia seeds, which are about the size of wheat, and asked for depth to plant. Their answers varied from one inch to two feet, just as do yours. Whose suggestions shall we follow? Do you not think we had better learn something about seeds before we attempt to plant them? To-day we shall learn how deep and how far apart to plant seeds.

Water Enters first through Micropyle near the Hilum. — (Give each pupil a bean which has started to sprout.) What does a seed need before it wakens? How does the water get into the seed? Look closely. Yes, there may be holes. Into this glass of warm boiled water I am going to drop two beans. (See Fig. 2, page 4 in text.) Notice what happens. Where are the bubbles coming from? The little opening which you see is called the micropyle and through it the first water enters. If you look closely at your bean you may find the micropyle. I am going to drop these beans into water. The micropyles are closed with vaseline. What happens? (The teacher should never hesitate to use the proper name when its need

is felt.) Here I have several peas in a pod. Notice how each pea is fastened to the pod. Examine the bean you have and tell me where you think it was attached to the pod. That place on the pea is called the hilum. If the water enters first near the hilum we must be careful to plant the seeds in what manner? Yes, with the hilum down or far enough beneath the soil to insure water entering the micropyle. How can we prove this? Bring in some plan that we may try later or experiment at home.

Water also Enters Seed through Coat by Osmosis after Sugar Has Begun to Form. — Carefully remove the covering of the seed in two halves. Do you suppose that water could pass directly through the cover? Is there any way to find out? Here, I have these two halves. In one I shall place a little sugar and shall float each in this tumbler of water. I am going to treat these walnut shells in the same way. Notice from day to day what happens. (See Fig. 9, page 15 in text.)

Seed Gets rid of Coat at Once. — What is the first thing the seed tries to do when it begins to pump water? If that is so, is the seed coat of value? How shall we find out? Yes, we now have another experiment to try. (Seeds put into water at the beginning of the lesson wrinkle. See Fig. 1, page 3 in text.)

If this seed were planted, what would come from it? Carefully pull the two parts open, leaving a hinge. How many can find the little bean, the little embryo, as it is called? What is the first thing needed by a young animal? What is the first thing needed by the embryo plant? Where is its food? What do you think would happen if we planted the embryo by itself? The food is stored in these *seed leaves*, or *cotyledons*. Yes, we will try it. This stored food is to feed the embryo until it can fix the roots and get its leaves to the sunlight, so which seed should we plant the deeper, the wheat seed or the bean? Would you like to know a general plan to follow? Seeds are usually planted at a depth ranging from three to five times their diameter.

Mono-, Di-, Polycotyledonous Plants. — (Having named the seed leaves as cotyledons develop the classification of plants into mono-, di-, and polycotyledonous divisions. Also draw attention to the

radicle and plumule. However, the essential fact to leave in the minds of the children is that the embryo, and usually its stored food, constitute the seed.)

How Far Apart to Plant Seeds. — How far apart shall we plant these radish seeds? These lettuce seeds? Your answers differ. We must know how far apart to plant seeds before going ahead. Notice the roots of the radish and the lettuce. (Knock the end out of a chalk box. Get old camera plates $3\frac{1}{4} \times 4\frac{1}{4}$ inches, clean, slip two into the grooves of the box. Place a piece of black cloth next to the glass and fill the box with fine soil. Several days before the lesson, plant lettuce and radish next to the glass. Between two plates of glass place two or three thicknesses of blotters. Next to the glass on the blotter sides place two pieces of black cloth. At one edge of the apparatus place corn seeds side by side between the cloth and the glass. Treat wheat seeds in a like manner on the reverse side. Stretch a rubber band around the apparatus to hold seeds and glass in place. Suspend in a jar of water. Observe results from day to day.) Now, who can tell me why radish seeds are planted closely together and lettuce seeds farther apart, since you know what the roots are for? According to our new knowledge how far apart shall we plant turnip seeds? Pansy seeds? Wheat? Corn?

Root and Top Space Usually Determine Distance Apart to Plant Seeds. — Just as different plants need different root space, so do they need variable top space. The cabbage needs plenty of top space to mature a fine large head. This factor must be remembered to help us in planting and transplanting.

Notes

These lessons may be given but once a week for one period, since their aim is to direct conduct in the school gardens which are soon to be started. A great deal of valuable material may be woven into each lesson if a teacher so desires, such as: methods used by Nature to bury her seeds, the reasons for doing this; seed dispersal, seed adaptations. The teacher should ever see beyond the seed, beyond the material at hand, to the larger lessons. Each study should

add its bit to emphasize the great study of evolution and its kindred subjects. Our suggestion, however, if time is limited, is to give only those things that direct immediate conduct now. Later the other factors may be taken up.

At the close of this lesson the children are ready to work understandingly in the preparation of the gardens. They know how to prepare a seed bed and why each step is to be taken. They know how to plant seeds. Logically, this is the time to start the school gardens. The following lessons should be given as time permits.

LESSON III

PROBLEM QUESTIONS

During the first two lessons on soils and plants certain problem questions have arisen. While some of the pupils may have experimented to solve the problems, a period should be taken to set up experiments designed to answer the questions. (See Introduction.)

Read or state the following problem questions to the children and let them select such as appeal to them.

1. Does the water enter first through the hilum?
2. Is the seed coat of value to the seed?
3. How deep shall seeds be planted?
4. Does the seed use much force in breaking open its coat?
5. What device is used by some seeds to bury themselves?
6. Shall one irrigate or sprinkle one's garden?
7. What effect has cultivation on loss of moisture? A mulch?
8. Why should one make the seed bed fine in texture?
9. Will seeds grow well in sand? In clay? In humus? Or better in a mixture of the three?
10. What is the effect of too much water on seeds?

Usually a class of forty children choose experiments in such a way that they work in groups of four and five.

With the experiments assigned, give definite suggestions to each group relative to their experiment or, better, let the children devise the experiment.

Experiment 1. — In chalk boxes filled with earth, bury six Windsor or lima beans half under the soil with the hilum exposed to the air. Plant six with the hilum down and lay six flat on the soil. Keep the surface moist and observe from day to day. Make records in notebooks. (See Fig. 3, page 5 in text.)

Experiment 2. — Put twelve beans in water over night. (Teacher should do this before the lesson.) Carefully remove the seed coats from six beans. Plant the twelve beans and give them all the same treatment.

Experiment 3. — Knock out one end of a chalk box. Slide two spoiled, clean camera plates $3\frac{1}{4} \times 4\frac{1}{4}$ inches into the grooves of the box. Place a black cloth against the glass and fill the box with moist earth or sawdust. Press seeds between the cloth and the glass at different depths. Determine best depth to plant seeds.

Experiment 4. — Fill a bottle with dry beans. Place the bottle in water. Observe results. (See Fig. 5, page 8 in text.)

Experiment 5. — Into a bunch of cotton place alfilaria seeds, foxtails, and oats. Observe results. Discuss other methods that Nature uses to bury seeds. (See Fig. 90, page 174 in text.)

Experiment 6. — Plant rows of seeds in two boxes. Give the same treatment to all. Measure out the same amount of water for each box. Sprinkle one box and irrigate the other. Watch results from day to day.

Experiment 7. — Fill two boxes of the same size with soil until they weigh the same. Add the same amount of water by weight to each. The following day carefully cultivate the surface of the soil in one box. Weigh both boxes each day. What happens?

Experiment 8. — Grow seeds in boxes containing cloddy soil and fine soil. Give the seeds the same treatment. Observe results.

Experiment 9. — Grow seeds in clay, sand, humus, and in mixtures of the three. Treat all boxes alike. Observe and draw conclusions.

Experiment 10. — Fill two tumblers with soil. Plant seeds in each. Keep one tumbler of soil moist. On the surface of the other soil keep water standing.

Notes

Soil to be used one day should be watered the preceding day and allowed to stand without disturbance over night. Do not water and stir soil at the same time.

Each experiment should be set up neatly and carefully. Small labels should be placed at the head of each seed row, indexing the kinds of seeds planted and the date. These labels may be purchased at a low price from seed houses or made from shingles.

In all cases be sure that the children know what the experiments are to teach so that they will direct conduct in the garden work. The children must also know the law of majorities, that one experiment does not always suffice, but that several demonstrations are necessary for proof. All sources for error must be pointed out and avoided so far as possible. When necessary, control or check experiments, for comparison should be used in children's experiments and teacher's demonstrations.

LESSON IV

THE NEEDS OF THE SEED AND THE PLANT

Have the children examine the progress of the experiments started at the previous lesson. Be sure that the aim of each experiment is understood. Apply the results to the garden work. Experiments 1, 2, 3, 6, 7, 8, 9, 10 are particularly of value in the direction of conduct. Make notes recording the progress of the problems.

Experiment (1) teaches that the hilum at least must be beneath the soil. Many seeds, such as the canna, cannot secure much water through their horny seed coats. This is the first necessity of the seed. In this case the coat is harmful and must be filed in order to let water in. Pine seeds germinate sooner if a hole is drilled in the seed coat at the germ end. Experiment (2) suggests conduct in the above direction. Experiment (3) enables one to formulate a rule that seeds are planted usually at a depth 3 to 5 times their diameter. Experiments 6 and 7 teach the fundamental prin-

ciple of water application and dry farming. Experiments 8, 9, 10 direct conduct in the selection and preparation of the seed bed, in application of water, and in planting seeds.

THE NEEDS OF SEEDS AND PLANTS

General Topic Aim. — Same as in Lesson II.

Specific Lesson Aim. — To teach that the embryo plant needs air, water, and warmth for growth — that the plant, free from the seed, needs sunshine in addition — in order that proper methods may be used in the garden to supply each.

THE LESSON

(The most interesting thing to a child is himself. The teacher should make the most of this in all school work.) Children, who can tell me what we need in order to live? You are right, we must all have food, water, sunshine, and warmth. Some day and possibly very soon I should like to know if you are getting each of these in the proper way. (See Lesson X.)

Little Difference between Low Form of Plant and Animal Life. — What is a seed, Fred? Correct. What is a plant? Your answers differ. What is an animal? Again you are puzzled. You do not define either one so as to shut out the other. And there is little wonder, for many of our brightest men and women cannot do this. There is a little living thing (picture on board) Uglena which seems to be both like an animal and a plant. This organism is found in the water. (See any text on Zoölogy or Biology.)

If an animal and a plant are so much alike what does the plant need? Are you sure that the embryo plant needs sunshine? What have we discovered that the seed tries to do as soon as it reaches the soil? Does the little plant within need sunshine? How can we find out? How shall we arrange the experiment? That is a good suggestion.

Plants Need Air. — Here are two bottles, a cork, and seeds. How can we prove that seeds and plants need air? We shall follow May's suggestion. (Arrange experiment and set aside, use cotton as the

seed medium. Use six- or eight-ounce bottles with wide mouths. Also suggest and set up this experiment — plant seeds in a tumblerful of soil, add water until all soil air is driven out, and set aside.)

FIG. 6.

Plants Need Warmth. — How can we find out if plants need warmth? How many know without experimenting? Yes, Geography tells us. However, let us devise some method with these seeds, the stove, and the coldest spot we can find. What shall we do? (Plant seeds in three bottles as in Fig. 6. Place one near the stove, one on the window sill inside, and one outside. Each should be given the same treatment as to water.)

Plants Need Food. — Do plants need food? How may we prove John's answer? (The pupils are slow in devising this experiment. Arrange five chalk boxes, put cotton, sawdust, sand, clay, and mixture of sand, humus, and clay in separate boxes. Plant the same kind of seed in each box and give all the same treatment. Fill another series of boxes with sawdust. Using the same amount of water add distilled water to one, tap water to another, distilled water containing a nitrate, distilled water containing a phosphate, and distilled water containing a potash salt to others. Or better, fill several beakers or tumblers partly full of distilled water, suspend a few of the same kind of seeds in the water by using mosquito netting. Cut the netting considerably larger than the circumference of a beaker, place over a beaker and fasten in place with a rubber band. With the finger force the sag in the netting to the surface of the water, and add the seeds. To prevent evaporation and to shut out bacteria cover the opening of the beaker with cotton. Add plant foods as desired to the different beakers, first making up 1 per cent solutions, etc. See Osterhout's "Experiments with Plants," pp. 137–140, listed in Appendix C. (For distilling water arrange a cake pan and two ordinary pans as shown in cut. Put water in the upper and lower pans and heat. Osterhout's "Experiment with Plants," page 137 for cut.)

In one box of sawdust or soil place three rows of Windsor beans. Later, as the seed leaves appear, break them off the plants in the first row. A week later treat the second row similarly. Observe from day to day. What is the function of the seed leaves?

The Embyro Plant Does Not Need Sunshine for Growth. The Plant Free at the Surface Does.—Think of the seed with its tough cover laying in the soil and tell me if the embryo plant needs sunshine. Devise some experiments with these plates, blotters, and seeds. (Place seed on the blotters in one plate and cover with another so as to shut out sunlight.) How shall we prove that plants need sunshine? (Start similar seeds in two boxes or bottles as in cut shown on the preceding page, place one in the dark and one in the light.)

NOTES

The children know that the plants need moisture. However, peas may be started in sawdust and after the plants come up they may be allowed to wilt. Add water to refresh them. Water not only conveys food to the plant but makes it plump and strong (turgid).

The apparatus for this lesson should be ready beforehand. If apparatus and room permit, it is best to let the children set up the experiments and take care of them. Keep them well arranged in the room, labeled as follows: "Do plants need air?" "Do plants need sunshine?" etc.

The next lesson will deal with the application of the results obtained from these experiments. Each experiment aims to direct conduct in the gardens.

Again let us suggest that the classroom experimental work should be sacrificed to the school garden if time does not allow for attention to both.

LESSON V

THE NEEDS OF THE SEED AND THE PLANT (Continued)

(THE experiments started at the previous lesson should be examined one by one and the results applied to the garden work.

Hold up the two bottles containing cotton and seeds. Do the embryo plants need air? Yes, there is no growth in the bottle which is corked. Notice this tumbler in which I planted seeds.) Again we find no growth. If the embryo plants need air how can we satisfy this need in the gardens?

(Develop the following facts by questions. The soil texture may be modified. Organic matter added to soil improves it. It opens the clay so that air circulates more freely. It binds the sand more closely. Organic matter prevents soil from puddling, thus keeping it free for the entrance of air.

The pore-space may be enlarged for the admittance of air. Soil is composed of varying particles of clay, sand, and humus. Air spaces exist at the meeting places of these particles. It follows that the size and number of the air spaces vary with the size of the particles. The number of pores in the sand is less than in the clay but the pores are larger. Thus the air space is increased in the more porous soil. Besides, the available water supply is much increased, and soil food more readily reaches the fine root hairs. Spading and cultivating makes porous soil. Seeds should not be planted when the soil is saturated because of lack of air.)

Do you remember this experiment? (Have the three bottles on the desk which were located in a cold, a normal, and a hot environment.) What does this experiment teach us? How can we plan so that the seeds we plant shall have warmth?

(Develop, by questioning, the following facts. The warmth of soils may be modified by altering the texture. Sand is warm, clay is cold. The method of modification is obvious. Seeds should not be planted during the cold wet season nor during the hot weather. Manure should not be added to a seed bed during the warm days.

The experiments to prove that plants need food will not be far enough along to direct conduct. The seed leaves of the first row of beans may be picked off. Follow this experiment and at the proper time point out how much the young plant depends on its seed food.

Pass out the plates containing seeds germinating in the dark and in the light.) Do embryo plants need light, class? Examine these

plants grown in the dark and in the light. Do maturing plants need sunlight? Why does this plant bend toward the window? Some plants do not need as much sunlight as others. The fern does best in a cool, damp, shaded spot, while sunshine is essential to most flowering plants. How does this experiment teach us what to do in the gardens?

(To insure equal distribution of sunlight show the children that the rows should be sown at right angles to the path of the sun across the sky — north and south. Teach that tall plants should not be grown so as to shade others, that seeds should not be started in shady spots, that young plants should be thinned out to prevent shading us well as for other reasons.)

LESSON VI

ROOTS

Unit of Instruction. — The work of the roots.

General Topic Aim. — To show the relationship between the roots and the life of the plant, to interest the children further in plant life.

Specific Lesson Aim. — To teach the function of roots (1) to hold the plant in place, (2) to furnish soil food.

The Lesson

Roots Hold Plants in the Soil. — (Ere this, in the development of the experiments started, the children will have come in contact with many roots. Pick up a beaker or tumbler in which seeds have developed roots and snip off the roots below the netting in which the seeds are suspended in the water.) Children, what is one use of roots to a plant? Corn roots often form a few inches above the soil to brace the stem.

The Root Furnishes Soil Food. — What will happen to this plant in a few days? Why will it die? (Have at hand the apparatus set up in Lesson IV to show that plants need food. The plants will be well under way by this time. Plants in the beaker containing

distilled water will probably be suffering for lack of food.) I am going to drop this salt into this beaker of water. What has become of the salt? A handful of radish seed if thrown into a barrel of apples would be lost to view. Where would the seeds go? Yes, among the apples. The particles of salt have gone between the water particles. The salt is said to be in solution. Now let us see if we can find some of the salt in this spoonful of water by evaporating the water. What do we see in the spoon? Taste it. Let us test this distilled water and the tap water in a similar way for substances in solution. Which contains the substances? Now, why do you think the plants in the distilled water are dying? Yes, the substances in solution are their food and there is no food in distilled water. (Be sure the children understand what distilled water is. Let them distill some if they have not done so. See cut, page 137, Osterhout's "Experiments with Plants.") Plants can use food only that is in solution. They need lime. What other substances have we found plants to need? (Examine experiments set up in Lesson IV.) Marble is cooked lime and may furnish food to a plant. Bones may furnish lime. If I drop this piece of marble or this piece of chalk into a beaker containing a plant, can the plant use the lime? Why not? Yes, it must be in solution.

Acids Turn Blue Litmus Paper Red.—I have a little acid in this test tube. Watch what happens when I put a little on the litmus paper. Substances that turn blue litmus paper red are acids. Observe what happens to this piece of marble (or chalk) when I drop it into the acid. (In a short time the marble disappears. The explanation of the singing noise due to bubbles of gas bursting, the testing of the gas, the cause of the resulting heat, may be taken up if you see fit. Any one of these suggests an intensely interesting field to children. One of the excellent features of agricultural study is the continuity of subjects offered. One study leads naturally to another. Forces at work are studied and the wholeness of the individual and his environment is ever evident. If you are skillful, you will watch the interest of your class and let it lead the children into new fields. However, you will avoid the danger illustrated by a hunter and his dog. He may let the dog run hither and thither

through water, over hills, and in every unlikely place, due to abounding dog life, with himself following blindly, and he will return with an empty bag; but let him check his dog as he starts on a mere wild chase, to let him go when results are liable to be obtained, and the hunter will return with birds in the bag. If the class takes a productive scent, follow, but direct the chase.)

Water Usually Shows the Presence of an Acid. — Let us test this well water for the presence of an acid. You see the litmus paper is turned slightly red. Suggest one way that mineral matter may be put in solution.

The Roots of Plants Secrete an Acid to Put Mineral Food in Solution. — Notice that I have put litmus paper in this glass funnel filled with sand. I shall plant these wheat seeds next to the litmus paper and water the sand with distilled water. (Tap water usually has an acid reaction.) What do you suppose will happen? We shall see if your theory is right. (As the roots develop they will be outlined in red on the litmus paper, which is placed around the funnel next the glass, showing the presence of an acid. This acid of course helps to put mineral food in solution.) Children, this experiment will tell us more about the usefulness of the root.

Nitrogen, Phosphorus, Potash, Lime, and the Other Foods may be Added to Soils. — What foods have we found plants to need? Nitrogen may be added to your gardens by working in dry cow's manure; phosphorus is best added by buying and applying a prepared fertilizer, although ground-up bone contains slowly available phosphorus; potash may be added by working in wood ashes; lime is necessary to add to some soils. However, our garden soil is rich, so we shall not add fertilizers this year.

Products such as wheat, oats, and tobacco use a great deal of nitrogen from the soil, and nitrogen is absolutely essential to plant growth. What will happen if wheat is grown year after year on the same land? Clover does not depend so much on the nitrogen of the soil, but obtains it from the air with the help of bacteria (minute plants that live in the bead-like swellings on its roots). These bunches on the roots of this clover are due to millions of bacteria. If it is true that bacteria help the clover plant in getting nitrogen

from the air, how shall we grow these two types of plants, clover and wheat? Yes, we will interchange them. This is called rotation of crops. Radishes and lettuce need different food from corn, so in our gardens we must rotate the crops. (See Fig. 7, which

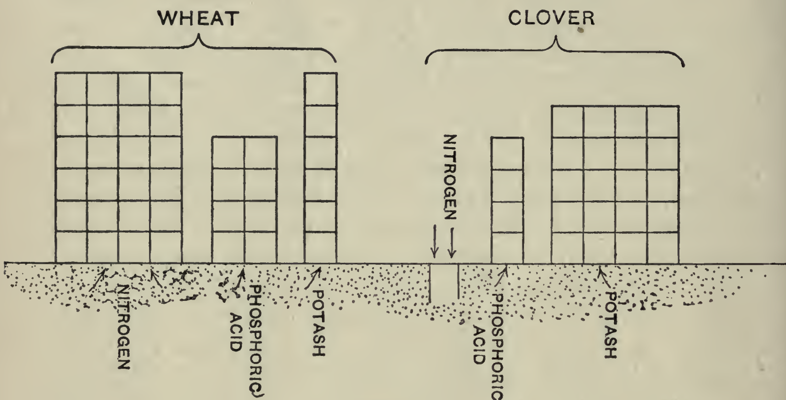


Fig. 7.

shows the relative amounts of plant food used by wheat and clover.)

Gravity, Presence of Moisture and of Food Cause the Roots to Grow Downward. — Why do you suppose roots grow in certain definite directions, usually downward? Why does this book fall if I withdraw my hand? Gravity is the most regular pull on the roots. These two experiments I prepared some time ago. This box with a wire netting bottom contains sawdust and seeds. The box has been resting with one end raised several inches. (See cut, page 95, Osterhout's "Experiments with Plants.") Look at the roots which were pulled through the netting by gravity. What are they doing? Why have some partially turned back? Because of the moisture. This experiment illustrates the same thing. This is a chalk box filled with sand. Imbedded in the sand is a porous pot filled with water. The seeds were planted between the glass front to the box and this black cloth (the cloth is used to keep

the seeds in view). Why are the roots bending toward the pot? (See cut, page 96, Osterhout's "Experiments with Plants.")

Surface Irrigation Causes Growth of Surface Roots and Later the Plants Suffer. — If roots seek moisture what is the danger of surface irrigation? What is the value of deep furrow irrigation?

The Root Hairs Pump Water and Food into the Main Root. — Here are many radish seeds growing on this sand. Pick one out as the dish is passed. What do you find clinging to the roots? What holds the particles of sand? These tiny rootlets are called root hairs. They are very fine and slip between the soil crumbs, taking up soil food which is in solution. (See Fig. 8, p. 13 in text.) (Review needs of plants as to air, etc., and the proper way to insure same to the plant.) Without these small root hairs the main root would have to be at least seventy-five times as large as it is.

The Food Gets into the Root through Osmosis. — Here are three carrot roots which I hollowed out yesterday. Two have stood in water and one as you see has not been near moisture. In one I placed sugar. Tell me what you observe. Yes, there is water in this one and the sugar is in solution. Where did the water come from? How do you know that it came from outside the root? Yes, our control experiments tell the story. There is no water in either. What caused the water to enter but one root? Where else have we found sugar doing this work? What is this process called? Thus the roots furnish soil food to the plants, but they furnish only about 3 per cent of the food needed by plants, if we do not count water itself as food. How and where do the plants get the other 97 per cent? (The teacher should remember that these figures pertain to the weight of plants when thoroughly dried.) Would you not like to know how the leaves work? Very well, we shall study them at the next lesson.

LESSON VII

THE STEM AND THE LEAVES

Unit of Instruction. — The work of the stem and the leaves.

General Topic Aim. — Same as in Lesson VI, except the relationship is between the stem, leaves, and the life of the plant.

Specific Lesson Aim. — To teach the function of stems and leaves.

The Lesson

The Stem Conveys Food, and Lifts Leaves, Fruit, and Seeds into the Air. — At the last lesson we learned that three per cent of the plant's food is furnished by the roots. How does some of this food get to the leaves? I shall cut open this stem of a calla lily which yesterday was placed in this basin of colored water. What is the main work of the stem? (Teacher blows on a dandelion ready to disperse its seeds.) What are these things flying around? To each little parachute there is a seed. What is the parachute for? Of what gain is it to the plant to scatter its seeds? Can you think of another use for the stem? Yes, the plant with the long stem is best prepared to scatter its seeds, other things being equal. What else does the stem lift into the air?

Leaves Throw off Moisture from the Plant; They are Foodmakers. — What was the test for acids? One can also test starch, but in a different way. Notice what happens to this starch as I add iodine. Iodine always turns starch blue. Do you suppose there is any starch in this corn seed? Let us test. Yes, you see there is. How do you suppose it got there? John thinks it came in with water. Let me add this starch to water. Does it dissolve? Then, can it reach the seed as starch? No, for starch is insoluble. However, starch is changed to sugar, which dissolves and is carried by the water where it is needed and then changed back to starch. Potato is made of starch and water mainly. The saliva in the mouth may change the starch to sugar and in that form we use it. There is something in the plant which does this same thing.

Starch is made of Carbon Dioxide and Water. — Set up the ap-

paratus as shown in cut. (Page 186, Fig. 105, Osterhout's "Experiments with Plants.") Place a little starch in the tube and heat gently. Water collects on the sides of the tube and the lime water in the tumbler turns milky, showing the presence of carbon dioxide. You may have to make carbon dioxide to show the lime water test. (Use marble and dilute hydrochloric acid.) Where does the water come from, Children? What gas is given off? Of what is starch made?

The Plant Takes in Carbon Dioxide and Water. — (Set up the apparatus as illustrated. Page 75, Fig. 139 of text.) Use laurel or magnolia branches. Fill the tube full of water, make air-tight, and place in the sun.) What causes the bubbles? Where does the air come from? Air contains carbon dioxide. Lime water exposed to the air turns milky, as you remember. If starch is composed of water and carbon dioxide, if the plant takes in carbon dioxide and water, and if we find starch in the seed, what conclusion may we draw? Yes, the plant must put water and carbon dioxide together to make the starch and the sugar. What is the most likely place for this process to take place? The leaf unites water and carbon dioxide to form elaborated foods, *e.g.* sugars, starch, proteids, etc. I have drawn on the board a cross section of a leaf. The green color represents chlorophyll grains. These green grains give the color to the leaf. (See cut, page 202, Fig. 116, Osterhout's "Experiments with Plants.") These little grains are like a steam engine to the plant. The sunlight is the fire, and sets the chlorophyll particles to work, the water and carbon dioxide are combined and may be thought of as the water, and the starch, the final result, is the steam.

Leaf Surface. — Plants have many methods of presenting and of limiting a large leaf surface. (Take the children on a field trip to point out leaf arrangements for offering a large leaf surface to the sunlight. See pages 78 and 79 of the text. On the same trip direct their attention to the methods of leaves to prevent loss of moisture (1) by rolling, (2) by hairy covering, (3) by thick epidermis, (4) by wax, gums, etc., (5) by changes in position, etc. Field trips should be made whenever possible.)

LESSON VIII

THE FLOWER

Unit of Instruction. — The work of the flower.

General Topic Aim. — The same as in Lesson VII with relationship of the flower to the plant.

Specific Lesson Aim. — To teach the parts of a flower; to point out the process of fertilization.

The Lesson

The Final Aim of a Plant is to Reproduce Itself. — What happens to most plants after they flower and go to seed? What happens to an alfalfa plant if it is cut before it goes to seed? What seems to be the main work of a plant? Would you not like to know how plants reproduce themselves, how new plants are formed?

The calyx, sepals, corolla petals, stamens, filament, anther, pollen, pistil, stigma, style, ovary, and ovules are the main parts of a flower. (Give to each child a specimen of a flower, carnation, flax, geranium, or any flower from a stone or a pome fruit tree, which is typical and has all the parts listed above.) Children, I dislike to tear flowers to pieces because of their beauty and fragrance and because of the pleasure they bring to people, but to-day we shall have to sacrifice these flowers in order to learn how new plants are made. On the board I have a drawing of this flower, naming the different parts. (Fig. 48, page 92 of the text.)

The Corolla is the Most Attractive Part of a Plant. — What is the most attractive part of your flower? What does the corolla attract? Your suggestions are good, but let us wait a few minutes before we definitely settle the question. Carefully remove the small parts which make the corolla. Count them. These are called petals. Sometimes it is necessary to know the number of petals before we can name a flower.

The Calyx and Sepals. — Look at the calyx, the green cup in which the corolla seemed to stand. The leaf-like parts are the sepals. The calyx supports the rest of the flower.

The Stamens and Pistil and Their Parts. — I shall not worry if you forget the other names I have given you, but I want you to remember that there are stamens, the male element, of the plant, and this is the pistil, the female element. These parts are essential to any plant, the others are not. Examine them closely. Carefully pull off a stamen. Notice the swollen part at the top. It is the anther. What is the yellow, powder-like substance? The long slender portion is the filament. These new names are on the board. Carefully pull off all the stamens. How many are there? The number of stamens often help in naming an unknown flower. What is left? Yes, this is the pistil. The enlarged top is the stigma, the swollen base is the ovary, and the slender stalk is the style. Cut the ovary in half with a sharp knife. What do you see? The tiny bodies are ovules or egg cells which will grow into seeds if they can. All of these parts are drawn and labeled on the board. In a few minutes we shall take time to copy them in our books. Some of you will remember these new names, some will forget them, but I hope none will forget the stamens and pistil and their use, which we are going to learn.

Pollination. — When the pistil of a plant gets ripe it forms a shiny covering of sticky liquid on the stigma. If a pollen grain falls into this liquid, it germinates and sends a long tube down the style, into the ovary, and finally into an ovule. The two elements are united and in time a seed develops which may be planted to produce a new plant. (Fig. 50, page 94 of text.) If you were to taste the sticky stuff, you would probably find it sweet like sirup. You may come forward one at a time to see the pollen grains beneath the microscope which I have germinated in sirup. Notice the long, root-like tube which normally penetrates the style. (Make a solution of fifteen grams of sugar in 100 centimeters of water. Put a few drops of the solution on microscopic slides and add a few grains of pollen from oak anthers, sweet peas, or nasturtiums. Place thin cover slips on each end of the slides to slightly raise the slides placed over the pollen and solution. Examine every three or four hours. To prevent the sugar solution from drying up, put the slides beneath a bell jar with a moist sponge to keep the air damp. Microscopic

slides and covers are not essential. Ordinary saucers will do to hold the weak sugar solution and an inverted teacup may take the place of the bell jar. A strong magnifying glass may do as a substitute for the microscope.) When you return to your seat make a drawing of what you saw.

Fertilization. — The union of the two elements, the pollen grain with the ovule, which I have told you about, is called fertilization. (See page 92 in text.) Children, it seems to me this is the most wonderful thing you can learn about plants. Nature's great problem has always been, *how to save life.* The pollen grains are alive when you take them from the stamen, but in a few hours or days usually they will die. The ovules in the ovary are alive, but if no pollen falls on the stigma, they cannot grow into seeds. Now you know the great secret of how Nature saves life and at the same time how the different kinds of plants are able to propagate themselves.

Cross-pollination. — Notice that the anthers in these flowers are elevated over the stigma but that there is no sticky substance on the stigma. Examine these flowers. Notice the position of the essential parts. Here, the stigma is above the anthers. Nature seems to be trying to prevent something. What is it? That is just it, she doesn't want the pollen to reach the stigma on the same parent plant. She tries to prevent self-pollination usually. There are instances, however, in which self-pollination seems to do no harm to the succeeding plants. In the great majority of cases continual self-pollination would result in less vigorous plants as new ones were formed. Since the union of a pollen grain and an ovule is necessary for the new seed pollen must travel from one flower to another. Observe the legs of this honeybee. What do you see? You have all noticed bees at work; what are they doing continually? What might they carry from flower to flower? To-morrow we will follow a bee and see how many flowers she visits. This is what Nature desires and this process of fertilizing the ovules of one flower with the pollen of another is called cross-fertilization. This makes the succeeding plants stronger. Many flowers have peculiar arrangements to insure cross-fertilization. (See cuts, page 306, Osterhout's "Experiments with Plants." Use footnote.)

(Take class on a field excursion to observe adaptations to insure fertilization. Study the relation of other animals to pollination.)

The Nectar and the Bright Corolla Attract Insects. — Why does the bee visit so many flowers? Yes, he is after nectar and pollen. How does she know where the nectar and pollen are? How do you know of the bargains in a large department store? Having entered the store how may you readily locate the drug department? How does the flower "advertise" the presence of nectar? The insect having been attracted to the flower by the bright corolla, how does it locate the nectar?

The Oneness of the Universe. — Thus we see how one factor depends upon another. The plant takes its food from the soil. The insects insure new plants by cross-pollination. The new plants feed animals and the animals and plants are eaten by us. The birds, as we shall learn, keep some insects from destroying plants.

Notes

1. There is little harm in the cautious use of animal and plant personification. The most interesting thing to a child is himself. This interest may be grafted into the matter under study. For example, "How do you get your food?" "How does the plant get its food?"

Personification if not carefully handled may lead to silly sentimentality, such as is illustrated in the following story: "Why, papa, how can you cut off the limbs of that tree? How would you like to have your arms cut off?" said a boy to his father as he was pruning a lone fruit tree. "What harm am I doing, and who suggested such things to you?" asked the father. Replied the boy, "Teacher says trees have life and are like animals, and, if so, doesn't it hurt them to cut off their arms?" Avoid injecting qualities into a flower or other plant which are not truly its attributes.

2. The pollination of flowers gives the teacher an opportunity to point out the relation between the male and the female elements. It gives the teacher opportunity to teach the children something about the matter of sex which is so carefully avoided at the expense

of thousands of dollars, untold misery, and many lives. Prudishness in this direction is an expensive characteristic of parents and teachers alike. See Dr. Eliot's very helpful article on "The Teaching of Sex Hygiene," in The Sierra Educational News for March, 1911.

PLANT PROPAGATION AND PLANT IMPROVEMENT

Chapters VIII, IX, and in "Agriculture for Schools of the Pacific Slope" should furnish most interesting suggestions for work in home and school gardens. Properly presented, the topics of the propagation and improvement of plants cannot fail to delight boys and girls of the early adolescent period.

Suggested Method of Approach. — Lesson VIII in this manual or the following. Review life histories of any common seed-bearing plants with which the pupils are familiar. What is always the end or fulfillment of the plant's work? For what purpose, then, has it been getting and storing up food? What are seeds? What is the relation of the flower to the seed? Those who do not know will learn in this chapter on "How Plants are Propagated."

Read first paragraph on page 91. The last sentence touches a most important consideration in regulating our tree fruit crops. When are the blossom buds formed on apple, peach, orange, etc.? Demonstrate second paragraph on page 91.

Flower and Fruit. — Read and have pupils name parts in various flowers. They should also perform the experiments on pages 92 and 93 of text. Other large flowers suitable for the emasculation experiment, page 92, are trillium, single rose, single poppy, single fuchsia, calla, canna, hibiscus, gladiolus, nasturtium, magnolia. Some plants bear distinct male and female flowers, for example, squash, corn, walnut. In these it is only necessary to cover the female flower in order to prevent pollination.[1]

On page 95, paragraph 1, the authors allude to a very important

[1] See the excellent chapters on "The Fertilization of Flowers" and "The Insect Pollinators" in "Farm Friends and Farm Foes" by C. M. Weed, Boston, D. C. Heath & Co.

principle in tree fruit growing and one which is not always understood. If in a region where apples, cherries, plums, or peaches are grown, have pupils find out what varieties bear well if planted in uniform blocks of a single variety. It is possible that no such orchards of apple and cherries will be found as it is the usual custom to mix or alternate varieties for the sake of cross-pollination.

On page 98 of text paragraphs 2, 3, and 4 touch on important commercial points in fruit handling which are again treated on pages 231 and 304. (See "The Handling of Fruit for Transportation" by G. H. Powell. Reprint Agriculture Yearbook. Sent free by the Secretary of Agriculture, Washington, D.C.)

Testing seeds (page 99 of text) should receive more attention than is suggested here. The percentage of viability of seed corn, for example, is an important factor in its improvement. For detailed direction see "Exercises in Elementary Agriculture," by D. J. Crosby. (Price 10 cents, apply to Superintendent of Documents, Washington, D.C.)

Do you know of any plants that do not make seeds? (Pupils may name banana, seedless orange, pomelo, apple, plum, etc.) How can such plants be propagated? (Pupils may suggest slips or cuttings, root-sprouts, budding and grafting.)

Other Ways of Propagating. — The various experiments and exercises given here comprise the most valuable garden work possible, and every effort should be made to provide facilities for it. For further details of propagation by seeds and cuttings see "Elementary Horticulture," by C. F. Palmer, Los Angeles State Normal School, pages 23 to 56, 50 cents; on all phases of plant propagation consult "Manual of Gardening," by L. H. Bailey (The Macmillan Company, $2).

How Plants are Improved. — This chapter and the one following may be used merely as supplementary reading with discussion, or they may serve as a starting point for most interesting observational and experimental study. The great fact of *variation* among living things — that no two plants are exactly alike and that among a large number of wild or cultivated plants one may find some which differ a good deal — should be impressed by means of a field lesson or the examina-

tion of specimens collected by the teacher. The value of such study in training the power of observation is great. Then, if followed by applying the principle of selection, as explained on pages 106 and 107 of the text, an alluring field will have been thrown open to the pupils and some will enter and enjoy it. State Experiment Station (Berkeley) Circular no. 46 on page 26 suggests experiments in plant improvement by means of selection, the idea being that such experiments should extend over a period of at least two years, and preferably three or four.

When pupils are trying to decide what crops or plants to choose for the experiment, lead them to look for those in which the most variation exists, then save seed from single plants separately and plant each lot of seed in a plot by itself. Repeat the selection of seed from single plants and watch results. Remember, it is not only the character of the single large flower or large head of wheat that determines what the next crop will be like, but the nature of the whole plant of which it is a part. If attempting to increase the yield of potatoes, it is not enough to pick out the largest or finest tubers from a pile. The seed potatoes must be selected when the plants are being dug, so as to take them from the *hills that yield the most tubers*. Potatoes also occasionally " set seed." Luther Burbank secured the Burbank potato by planting a seed that he found in a seed ball in a field of Early Rose potatoes. For suggestions on improving California wheats teachers should read Experiment Station Bulletin No. 211, " How to Improve California Wheats," by G. W. Shaw, Berkeley, Cal.

It will hardly be possible to attempt cross-pollination experiments in the school garden. But there is no reason why the bright boy or girl who wishes to try it at home should not be encouraged to do so. When frost occurs or there are epidemics of plant diseases such as potato or tomato blight, alfalfa rust or leaf spot, wheat rust or smut, asparagus rust, etc., it would be worth while to have pupils look through the damaged fields and mark plants that have escaped injury. Disease-resistant or hardy varieties are sometimes started in this way. (See page 124 of text.)

Poor Crops and How to Get Better Ones. — The first part of

Chapter XI (pages 125 to 131) deals with principles of the greatest importance in the business of making agriculture *pay*. The average American farmer is neglecting some of these fundamental principles. That is why the United States produces so much less to the acre than European countries. Note the comparison in the table given below: —

BUSHELS PER ACRE [1]

Crop	Eight Foreign Countries	United States
Wheat	28.42	12.5
Rye	24.5	12.4
Oats	43.5	31.9
Barley	34.9	26.8
Potatoes	180.23	93.0

A few years ago wheat was grown in many sections where people think it cannot be raised profitably now. It is said that the soil is "worn out," and that only rye or barley will pay, because such a small yield of wheat per acre is obtained. It is probable that the farmers who say this are neglecting three important principles. They have usually been plowing shallow and to about the same depth (page 127 of text) and have tried to grow nothing but wheat year after year (page 126 of text). These two practices have resulted in loss of humus (page 128 of text) which means less plant food and a soil that bakes and turns up in clods when plowed instead of being friable.

Now what should these farmers do? If their soil is like that of most semiarid regions (*i.e.* uniform to a depth of one foot more) they should plow deeper some years. Even this one change in practice will usually bring an increased yield. (Note warning, bottom of page 127 of text.) Then if a crop of field peas or vetch is grown and plowed under in the spring, the soil will be greatly benefited by this addition of humus, as the increased yield will show. This is the simplest kind of crop rotation. (Cf. Lesson VI in this manual.) But even this may not be considered practicable by the man who is *ranching* on an extensive scale. It is the *intensive farmer*

[1] From U. S. Census of 1900.

who is content to handle a smaller tract of land, but would handle it scientifically, who will practice regular rotation of crops as explained on pages 125 and 126. Such farmers will, of course, depend upon other products beside wheat or the staple crop of the region. They may have an alfalfa field which lasts for several years and supplies hay and pasture for stock. (See "Types of Farming in the United States," by W. J. Spillman, Reprint from Yearbook of Agriculture and "Replanning a Farm for Profit," by Smith and Froley, Farmers' Bulletin 370. Both sent free by Secretary of Agriculture, Washington, D.C.)

In all the above considerations, as also in the treatment of "drainage" and "alkali soils" the teacher must be guided by local conditions and practice among the farmers. Therefore, it is highly important before allowing the class to take up this portion of the book that the teacher should make a personal study among the farms of the region, learning the principal types of soil and how they are handled in growing grain, alfalfa, beets, beans, fruit, or other staple crops. Results of far-reaching importance can be secured by planning the school garden experiments so as to demonstrate to the pupils what is right and wrong in the culture of some crop grown in the locality. When in doubt as to what is the best practice consult several successful farmers, and if still in doubt, write to the Agricultural Experiment Station at Berkeley, for information.

Fertilization and Fertilizers. — There may be a good many points in connection with the subject of fertilizers about which teachers are uncertain or at a loss to know what is best. But there is one proposition concerning which they need have no fear of going wrong, and that is the importance of the correct use of farmyard manure. This is well set forth in the text (Chapter XII), and it is our purpose merely to supplement it with a few suggestions. America is known as a wasteful nation and the Western states are called the most profligate of natural resources. On the other hand, the thriftiness of the Swiss peasant is sometimes measured by the size of the manure pile. This is merely the compost heap recommended on page 140 of the text. There should be a place for the compost heap in connection with every school garden and the pupils should be taught to turn all waste animal and vegetable matter into fertilizers.

The value of native leguminous plants as hosts for nitrogen-fixing bacteria makes an interesting observational and experimental study. The problem-question would be something like this: Farmers now buy seed of Hairy Vetch and Canadian Field Pea and sow them for green manure crops. Have we any wild legumes growing hereabouts that will do as well or better? Have pupils bring fresh specimens of all the native clovers, lupines, vetches, and peas they can find. Examine for number and size of root nodules. (Page 142 of text, Fig. 75.) Specimens should be carefully dug up and the soil shaken or washed from the roots. After deciding which kinds bear the most nodules pupils may locate more plants and gather the seed when it is ripe. This can be planted in a plot next year alongside a plot of Hairy Vetch or Canadian Field Pea. The green crops should be spaded under at blossom time and a little later a crop of lettuce may be set out on each and on a third plot that has had no green manure and no stable manure. Compare the crops of lettuce raised on the three plots.

The use of commercial fertilizers is a question of growing importance. The relative value of nitrates, phosphates, and potash salts and of various combinations of these compounds may be shown by demonstration or observation plots. By corresponding with some fertilizer company the teacher or clerk can secure a few pounds of each of the three essential ingredients in commercial fertilizers and the teacher can lay off a series of plots, have the class spade in the fertilizer, and plant some staple crop. If the soil is heavy clay or adobe, an experiment in *liming* may well be made. Try different quantities on the same sized plots so as to determine the amount per square rod that will bring your soil into best tilth.

LESSON IX

AN INSECT LESSON

Unit of Instruction. — The cabbage aphis.

General Topic Aim. — To interest the children in insect life through the cabbage aphis, since insects make one element in their

environment which must be reckoned with; to teach the relation between insect life and other life.

Specific Lesson Aim. — To teach the children to recognize the cabbage aphis; to teach its economic status; to determine a method of prevention and control.

Children's Aim. — "We are going to try to save our cabbages by spraying to kill the aphides."

Lesson 1. — Development of Lesson.

The Business of the Aphis and All Insect Life. — Children, what is your father's business? Very good. Why does your father sell groceries, May? What does he want with the money? Then you believe that the business of your father is to obtain food for himself, you, and the rest of his family? Look at the aphides closely. What is the main business of the aphides? What are they doing? What is their food?

Insects Known by Their Work. — Look at your individual plants closely and compare with these plants that are unaffected. What differences do you notice? Look at these other cabbage leaves free from aphides. Did insects similar to the aphides attack these? How do you know, Fred? "Because the aphides suck their food while these cabbage leaves have been eaten."

Manner of Getting Food and Study of Mouth Parts. — How are they getting food from the cabbage leaves? You may each take one of the aphides. With these magnifying glasses look closely at the mouth parts. What do you find? What other insect that has such a piercing tube for part of its mouth bothers us in summer evenings? How does the mosquito get its food? Now tell me how the aphides are getting the food from the plants. You may each take one of these hectograph copies showing an aphis at work.

Method of Control Determined by the Mouth Parts. — Knowing how these insects get their food, how shall we kill them? It would be useless to put poison on the leaves as Albert has explained, and John has told us that poison placed in the sap would kill the trees. If we desired to kill the mosquitoes, it would be useless to put poison on our hands and decidedly dangerous to poison our blood, so we kill them with direct slapping or direct contact.

Spraying. — We shall kill these aphides by "striking" or "slapping" them directly with kerosene and water. You have probably watched your father put kerosene on a rusty bolt to cut the rust in order to loosen the nut, and you know how kerosene must penetrate the smallest places. Insects breathe, as Fannie has told us, through spiracles, or little openings, in their bodies. The kerosene suffocates the insects.

Making the Spray. — As you have noticed, I have mixed one part of kerosene to fifteen of water. Let us drop some upon these aphides. They do not like it. Now watch while I spray my cabbages, then you may spray yours. Be careful in spraying not to waste the spray. Why? Kerosene is not only expensive but too much of it will kill young trees. It is a good plan to spray on bright days. Why?

Succeeding Lessons

Lesson 2. — Increase and dispersal of the aphides.

Lesson 3. — Adaptations, enemies, protective coloration, etc.

Lesson 4. — Comparison of other aphides and insects to the type.

Lesson 5. — A visit to surrounding gardens in order to compare the gardener's methods with those of the class. Estimate the amount of damage done by the insects.

Notes

This lesson, or one similar to it, should be taken up only as the aphides begin to attack the cabbages.

The immediate aim is control, so the steps in the lesson should be determined by this fact. It is often necessary, at the start, to study the life history of an insect in order to determine the vulnerable spot. If this is known, the steps in the lesson should be (1) study of mouth parts, (2) method of control, (3) application of the methods, (4) prevention.

In following the life history of an insect or an animal such as the frog, by all means have the history under way in the schoolroom. An ordinary lamp chimney closed at the top with mosquito netting

and placed in a plant pot filled with soil makes an excellent breeding place for insects. Do not hurry life-history study.

It is hardly necessary to suggest to teachers the continual use of specimens, pictures, hectograph drawings, etc., in presenting these lessons.

Under natural checks for insect life the teacher and the class are naturally brought in touch with the birds. The conservation of bird life is a vital subject to our future welfare. To encourage bird protection, the " sky gems " should receive careful study. The study should be made through field excursions.

CHILDREN AND HEALTH

The child is the index of the man. Upon the children rests the future of our country. One great birthright left to the children is that of good health. The school and the home should teach the child how to live correctly. They should conserve the clear eyes and the red cheeks.

Do children need help as to hygienic conditions? Tables of statistics answer in the affirmative and these tables are of value in giving the index as to the health of the children.

Out of 442,287 children examined for defective vision, 100,000 were defective. Out of 458,965 children examined, 29,350 had defective hearing, 4518 out of 26,534 had adenoids.

Defective eyes, defective ears, adenoids, and other defects, each has a special effect and they all have a common effect on the developing child. Children are not getting a square deal. The child with adenoids, with defective eyes, or defective ears is scolded, punished, and ridiculed as an ignoramus until a sweet disposition is soured, the faith of the child-heart is blighted, and another character is twisted. The school, and in many cases the home, with their steam-roller method, produce another candidate for the juvenile court. The great majority of children who pass through the juvenile court are physically defective.

The home and the school should work hand in hand in this matter. Just as the home in so many cases is failing to give the child its

health right, so is the school. We have much reason to be optimistic, for there is a tendency in the right direction for better health conditions in the school. Medical supervisors are in charge in many cities. However, the work of these men should not be so much to tell the boy that his hearing is defective as to prevent him from becoming thus deficient. To work not so much with the abnormal child as to prevent the abnormal child. In other words, teach the parents at home and the children at school how to get fresh air, how to eat and bathe correctly, how to prevent the hundred and one minor ailments which twist the otherwise normal development. If one could but look into the mouths of hundreds of children, it would open one's eyes to the inefficiency that we sow as a race between the ages of one and fifteen. We would not treat colts as we do children. We would not turn colts into an alfalfa patch, yet we let children roam as they please from cheap candy to coffee and hot cakes, from the community drinking cup to public places laden with poisonous air. Habits are thus formed which produce not only uncleanly mouths but place a continuous strain upon the system, paid for later in terms of dull eyes, white cheeks, and low morals.

It is because of the urgent need that teachers should know how to improve their pupils' health that the following suggestions are included in this manual.

LESSON X

HYGIENE

In dealing with children one must (1) make them feel the need of the work, (2) use active, living material, (3) give opportunity for motor expression.

Introduce the hygienic work with bacteria in mass effect, avoiding the use of the microscope.

Bring a mushroom to class and study its general make-up. Draw attention to the spores, countless in number. Blow some of the spores into space, noting their disappearance. In two dishes, one exposed to the air, place moist bread. Observe from day to day.

This demonstration draws the attention of the children to the fact that the atmosphere is filled with minute germs.

The Hygiene of the Individual. — Prepare gelatin cultures as follows: To an eight-ounce bottle three fourths full of water add two tablespoonfuls of ordinary cooking gelatin and a drop or two of strained honey. Place the bottle in boiling water until all solids are in solution. Add with a stirring rod just enough ammonia to make the solution basic in reaction (turns red litmus paper blue).

1. Sterilize test tubes, bottles, petri dishes, etc., which are to hold the cultures. A sterilizer may be made cheaply as follows: Place in the bottom of an ordinary tin pail, wire netting with the corners bent down so as to raise the netting two or three inches from the bottom. Add water to the depth of one and one half to two inches. Place apparatus to be sterilized on this netting in the pail, cover, and set over a flame. Sterilize for thirty minutes. Pour the gelatin into the test tubes, etc., and sterilize. To be absolutely sure of pure cultures sterilize for thirty minutes on three different days. Bacteria in the spore stage are very resistant. Let the children do most of this work. Let the culture medium cool. Sterilize a knitting needle or a hairpin by holding over a flame, rub across the teeth, remove the cotton plug of a tube, stab quickly into the test tube containing the gelatin medium, withdraw, and plug again with cotton. (See page 251 in text.) In a similar manner make "stab" cultures from the finger nails, from different places on the skin, from lead pencils and the many other instruments that are put into the mouth.

Press the lips to a gelatin medium in a petri dish, cover, and set aside. Touch the fingers to a similar preparation, wash the fingers, and again touch a gelatin preparation.

In a few days the culture medium will be filled with bacterial growth, impressing upon the children the need of cleanliness and other hygienic measures. The cultures from the teeth and lips, lead pencils, etc., point the way to mouth hygiene. Too much of one's environment goes into the mouth. Children are eating too many carbohydrates, too many soft foods. These ferment in the stomach and keep the teeth bathed in an acid environment, producing early

decay. Forty-five children out of sixty questioned had eaten hot cakes, sirup, and mush for breakfast.

The cultures made from the fingers point to cleanliness of the skin, etc.

2. Add a little saliva and water to a test tube containing a piece of boiled potato the size of the thumb nail. Substitute in another test tube the same amount of potato carefully broken up. Keep both tubes at body temperature (95 to 100 degrees Fahrenheit). In a few hours test both for sugar. For this purpose use Fehling's Solution, which you can buy from a druggist. It should be freshly made up. Pour off the water and saliva, add a little of the Fehling's Solution, and heat for two or three minutes; then set aside. A reddish sediment indicates the presence of sugar. It may not appear at once.

The main reason for careful mastication is to present a large surface for the action of diastase (the active principle in saliva), in changing starch to sugar.

3. Prepare a flat bottle with gelatin culture medium. Catch a house fly and let it walk about on the culture medium. Observe results from day to day. Such a demonstration is more eloquent than days of talking about the harmfulness of the house fly. Avoid letting air into the bottle. (See page 263 in text.)

Bacteria are so closely related to the health and happiness of the individual that each class should spend at least two weeks of its school life in their study.

4. In a previous lesson you developed the needs of animals and hinted to the class that you wished to find if the children were getting air, food, sunshine, and warmth in a hygienic manner. Question the children as to the ventilation of their sleeping rooms at night and ask yourself if the schoolroom is properly ventilated. Very likely the air cultures answer this question in the negative. Show the children that oxidation in the animal means life. Answers to questions relative to food consumption invariably indicate improper food. Carbohydrates and soft foods predominate in the diet.

The following questions properly answered will index the life and environment of the children.

Questions

1. Do you sleep on a feather bed or a mattress? 2. Do you sleep between blankets or sheets? 3. How many windows in the bedroom are open each night and how far open? 4. Do you sleep in your undergarments? 5. Do you take a cold bath in the morning? 6. Do you lie abed in the morning, or rise at an early hour regularly? 7. Do you rinse out your mouth, clean your teeth, and drink a good deal of water in the morning? 8. What do you eat for breakfast? What do you drink? How long does it take you to eat your breakfast? 9. Do you play games outside with the other children? 10. Is your schoolroom well ventilated? 11. Does your teacher open the windows at recess? 12. Is a dry broom used in sweeping the schoolroom? 13. Are the desks dusted with a dry duster? 14. Is your desk too large or too small for you? 15. Does enough light fall upon your desk? 16. Where do you get drinking water at school and how?

These questions are suggestive only. For a more complete set see Dr. Allen's "Civics and Health," or Dr. Hoag's "Health Index of Children."

Be sure that the studies of bacterial cultures are applied in the direction of conduct.

LESSON XI

STUDY OF THE WEATHER

Unit of Instruction. — The weather.

General Topic Aims. — The relationship existing between the weather and plant and animal life; the value of the system of weather bureaus.

Specific Lesson Aims. — (These aims are to be realized in a series of lessons.) (1) To make and to collect apparatus for the bureau (Write to Washington, D.C., for "The Weather Bureau and the Public Schools" by J. R. Weeks — reprint of year 1907; also ask the Kansas State Agricultural College, Manhattan, Kansas, for a leaflet on "Some Weather Studies" issued in September, 1909),

(2) to elect the weather prophet, (3) to record weather changes and condition of plant and animal life, (4) to study the forces working upon the different pieces of apparatus (the weather bureau may unify a general elementary science course for a term's work in one of the higher grades), (5) to teach that since man cannot alter the climate of his locality his success depends upon seed selection, crop rotation, and conservation of moisture.

Organize a Weather Bureau. — Select a spot near the gardens and erect a shelter to hold a barometer, a maximum and minimum thermometer, a magnetic needle, hygrometer, and a centigrade thermometer. At one side arrange a place for a rain gauge. Upon the small protecting roof place a windmill and wind vane (made by the boys). Much of the above apparatus can be made by the children. Correspond with the State Weather Observer for suggestions.

After the apparatus is in place, ask the State Observer for a set of observational blanks and request that the daily weather chart be mailed to you. In addition to the regular readings desired by the state, have the children keep individual and class charts, noting the following points: Dates, clear or cloudy, kinds of clouds, amount of precipitation, air pressure, temperature of atmosphere and soil, presence of dew or frost, direction of wind.

Have the children elect a weather prophet from their number whose duty is to predict the approaching changes in the weather. The predictions should be posted in the schoolroom daily. The girls will enjoy making the flags. See bulletin "Some Weather Studies." By studying the relation between clouds, pressure of air, winds, and by observing the state weather chart received daily, the children will soon become quite expert in determining approaching changes.

A careful study of one month's readings will point out the relations that winds, clouds, etc., bear to the weather conditions and to each other. It will also point out the relation of weather phenomena to plant life, thus indicating the value of weather study as typified in the United States weather bureaus.

Much time should be spent in the study of the forces that are grouped around and act upon the apparatus of the school bureau.

Point out how man has utilized these forces in working out his own comfort. He has used the wind to pump his water, pointed out by the small windmill; magnetism to determine direction, illustrated by the needle; pressure of air, change of temperature, etc., to save his fruit. Man's progress is determined by this ability to utilize Nature's forces in manufacturing power to reduce his own friction in living.

In the study of heat (thermometer), pressure of air (barometer) and the other forces represented, remember that isolation of any subject means wasted energy. These forces should be studied to the end of their use in determining future conduct. That heat is poorly conducted by wool, as an isolated fact, means nothing, but if knowledge of the fact guides one in the selection of clothing, it means much.

Study magnetism in connection with the magnetic needle, the relation of evaporation and moisture content to temperature, illustrated by the hygrometer. Avoid detailed theoretical study; show enough of the properties of each force that the children may understand its nature, then demonstrate how man has worked each force into his welfare through machines.

Note. — A hygrometer may be made by suspending a cloth in a cobalt solution.

APPENDIX A

Outline of Agricultural Nature-Study by Groups[1]

Group I, Grades 1 and 2

Character of Instruction

Observation, identification, oral description; for general knowledge of immediate environment: the weather, wild and cultivated plants and trees, insects, earthworms, wild and domestic animals, common birds and reptiles; seeds, how they sprout; seed distribution; plants, how they grow; bulbs grown in water.

Garden Phase

School garden, individual plots. Plant and grow common, hardy, large-seeded vegetables, such as radishes, dwarf peas, beets, onions from sets, and one or two quick-growing flowers, such as dwarf nasturtiums, dwarf sweet peas, four-o'clocks. Demonstration lessons in planting and cultivating given by teacher.

Group II, Grades 3 to 5

Character of Instruction

Observation and comparison, practice in identification, oral and written description. Add to general knowledge and specialize in correlation with home geography. Observe wild and cultivated plants and trees, "dry-weather" plants, pond plants, economic plants and their uses; mammals, birds, fish, the mosquito and other economic insects; physical nature study.

Garden Phase

School garden, individual plots, and home garden.

(*a*) Plant and grow vegetables and flowers requiring more skill than those recommended for Group I. (*b*) Plant and grow typical crop plants of the region, giving some attention to varieties, harvesting, and methods of handling raw materials. (*c*) Begin experimental study of tree growing and plant propagation in the

[1] Adapted from "Suggestions for Garden Work in California Schools," Circular 46, Agricultural Experiment Station, Berkeley, Cal.

Begin organization of school or class "Nature-study clubs" in the fifth grade, making a "club meeting" of the nature-study period. Have reports on the experiments in tree growing and plant propagation in home and school gardens, and any other nature-study topics.

fifth grade. (*d*) Encourage the collection of native plants, shrubs, and trees for the school garden (community plot) or home gardens. This phase deserves more attention. Do not hesitate because you do not know botanical names. Get acquainted with the plants and use common names.

Group III, Grades 6 to 8

Character of Instruction

Observation, comparison, judgment. Study objects, as above, within and beyond horizon of children's observation; introduce bulletins, textbooks, and reference-books as sources of information, particularly as follows: —

For the sixth grade, U. S. D. A. bulletins and circulars on plant propagation, plant improvement, and forestry.

For the seventh grade, texts and bulletins on agriculture and horticulture.

For the eighth grade, texts, bulletins, and laboratory work on crop and animal production, farm machinery and buildings.

Emphasize outdoor and indoor experimental work in sixth and seventh grades.

The comparative study of root systems of crop plants may be made a valuable indoor adjunct

Garden Phase

School and home gardens.

Sixth Grade: (*a*) Continue study of plant propagation, both in individual plots and the community nursery, where seedlings and cuttings for budding and grafting should have been started the previous year. (*b*) Encourage pupils to experiment at home and to make observations and reports in connection with their indoor study or club meetings. Conduct excursions. (*c*) Reserve "problem plots" for the purpose of settling disputed questions or giving demonstrations. Or (*d*) crop improvement through seed selection may be the chief line of study for the year with plant propagation and forestry subordinate.

Seventh Grade: (*a*) Application of indoor experimental study in soils and plant growth to problems in irrigation, cultiva-

of the outdoor work in these grades.

NOTE. — It will be recognized that the work suggested for grammar grades is not all observational study. But it is intended that nature-study ideals shall obtain and that the nature-study method shall be used as far as practicable. The value of *experimental work*, doing, seeing, and inferring by the pupils themselves, cannot be overemphasized, providing the course of experiments is well planned and consistently carried out.

tion, fertilizing, crop rotation, seed and soil inoculation. (*b*) Continue or begin work in crop improvement or amelioration of some wild plant. (*c*) Encourage pupils to grow crops and domestic animals at home, keeping account of labor, fertilizers, feed, gross and net returns.

Eighth Grade: Experimental work of Seventh Grade continued. If the study of crop or plant improvement has been successfully introduced, pupils of this grade will wish to continue their experiments at home.

APPENDIX B

Plants that Thrive with Comparatively Large Amounts of Water [1]

VEGETABLES

Name	*Time to plant*	*How long to grow*
Artichoke	— Seeds, Jan.–Feb. (in boxes)	1 year
Artichoke	— Roots, Nov.–Mar.	1 year
Asparagus	— Seeds, Feb.–Mar. (in beds)	2–3 years
Asparagus	— Roots, March	9–12 months
Beans (string)	— Feb.–Apr. after frost	2–3 months
Beets	— Aug.–Oct., Jan.–Apr.	3–5 months
Broccoli	— Same as spring or winter cabbage.	
Brussels sprouts	— Same as last.	
Cabbage	— For early spring, Sept.–Oct.	3–7 months
Cabbage	— For summer and fall, Feb.–Mar.	3–4 months
Cabbage	— For winter, June–Aug.	4–5 months
Cauliflower	— Same as spring and winter cabbage.	
Carrot	— Any month except June and July	4–6 months
Celery	— Feb.–Apr. (in boxes)	6–8 months

[1] From "Suggestions for Garden Work in California Schools," Circular 46, Agricultural Experiment Station, Berkeley, Cal.

Vegetables (*Continued*)

Name — *Time to plant*	*How long to grow*
Celeriac — Same as celery.	
Chard — Same as beet.	
Chive (Cive) — Same as onion; sets or clumps.	
Corn (sweet) — Mar.–June, Aug.–Sept. . . .	2–3 months
Collards — Same as summer cabbage.	
Corn-salad — Aug.–Oct., Jan.–Apr.	6–8 months
Cucumber — Mar.–May	2 months
Endive — Aug.–Apr.	6–8 months
Garlic — Nov.–Mar., sets	6–8 months
Kale (Borecole) — Aug.–May	4–6 months
Kohlrabi — Aug.–Nov., Jan.–Apr.	4 months
Leek — Sept.–May	6 months
Lettuce — Aug.–May	4–6 weeks
Okra (Gumbo) — Mar.–May	2–3 months
Onion — Seed, Feb.–May, Aug.–Nov. . . .	9–12 months
Onion — Sets, Oct.–Apr.	2–3 months
Parsley — Aug.–May	2 months
Parsnip — Aug.–Nov., Feb.–Apr.	8–16 months
Peas — Every month	2–5 months
Peppergrass (Cress) — Aug.–May	4–6 weeks
Potato, Irish — Plants, Feb.–May, Aug.–Sept.	2–4 months
Potato, Sweet — Plants, Apr.–May	3–4 months
Radish — Every month	1–2 months
Radish (winter) — Aug.–Sept.	4 months
Rhubarb — Plants, Nov.–Apr.	1 year
Salsify — Feb.–Apr.	6–8 months
Spinach — Every month	6–10 weeks
Sweet Potato — Plants, Apr.–June	4–6 months
Tomato— Seeds, Feb.–Apr.	3–5 months
Tomato — Plants, Mar.–May	3–5 months
Turnips — Aug.–Nov., Feb.–Apr.	3 months

Annual Flowers

Name — *Time to plant*	*How long to grow*
Aster — Jan.–Feb. (boxes), Mar.–Apr., Aug.–Oct.	5–7 months
Balloon Vine — Mar.–Apr., after frost . . .	Rapid climber

Balsam — Feb.–Mar.	4 months
Bean (Scarlet Runner) — Apr.–May	2–3 months
Calliopsis — Oct.–May	3–4 months
Chrysanthemum — Feb.–Mar.	3–5 months
Clarkia — Sept.–Nov., Feb.–Mar.	4 months
Collinsia — Sept.–Nov., Feb.–Mar.	3 months
Coreopsis — Sept.–Nov.	8–10 months
Cosmos — Oct.–June	3–4 months
Dianthus (Pinks) — Sept.–Oct. (beds)	3 months
Dianthus — Jan.–Mar. (boxes)	3 months
Gilliflower (see Stock).	
Godetia — Dec.–Feb.	4 months
Gypsophila muralis (Baby's Breath) — Jan.–Mar.	3–4 months
Hyacinth — Bulbs, Sept.–Jan.	Spring flowering
Japanese Hop — Mar.–Apr.	Rapid climber
Larkspur — Sept.–Mar.	3 months
Lobelia (dwarf) — Aug.–Oct., Mar.–May (boxes)	3 months
Marigold — Jan.–Mar.	4 months
Mignonette — Sept.–Mar.	2–3 months
Mina lobatas (climber) — Feb.–Apr.	6 months
Morning Glory (climbing) — Feb.–Apr.	3 months
Narcissus — Bulbs, Sept.–Jan.	Spring flowering
Nemophila (Baby Blue Eyes) — Feb.–Apr.	2–3 months
Nigella (Love-in-a-Mist) — Sept.–Mar.	3 months
Pansy — Sept.–Oct. (boxes), Jan.–Mar.	3–4 months
Phlox drummondii — Sept.–Mar.	3–4 months
Platystemon (Cream Cups) — After first rains	3 months
Poppy — Sept.–Nov., Feb.–Mar.	3–4 months
Salpiglossis — Feb.–Apr., Sept.–Oct.	3 months
Scabiosa — Sept.–Oct. (boxes), Feb.–Apr.	4 months
Snail Vine — Spring after frost	6 months
Stock, Ten Weeks — Aug.–Sept., Jan.–Mar. (boxes)	3 months
Sweet Pea — Sept.–Feb.	4–6 months
Sweet Pea — Early varieties, Aug.–Feb.	3–4 months
Sweet Pea — Dwarf varieties, Sept.–Feb.	4–6 months
Zinnia — Feb.–Apr.	3 months

Perennial Flowers

Name / *Time to plant*	*How long to grow*
Bellis (Double Daisy) — Feb.–Apr., Aug., Sept.	6–8 months
Columbine — Sept.–Oct.	9 months
Canna — Seeds, Feb.–Mar. (boxes); Apr.	8–10 months
Canna — Tubers, spring	2–3 months
Canterbury Bells — Aug.–Sept., Mar.–May	12 months
Carnation — Sept.–Oct. (beds); Nov.–Apr. (boxes)	6–12 months
Centauria (Dusty Miller) — Mar.–May (boxes)	Ornamental plant
Chrysanthemum — Plants, Apr.–June	5–6 months
Daisy — Sept.–May	3 months
Dahlia — Seeds, Jan.–Mar. (boxes); Apr. (beds)	7–10 months
Dahlia — Roots, Mar.–May	5 months
Freesia — Seeds, Feb.–Apr.	2 years
Freesia — Bulbs, Sept.–Nov.	4 months
Forget-Me-Not — Sept.–Nov., Mar.–May	6 months
Gladiolus — Seeds, Feb.–Apr.	2 years
Gladiolus — Bulbs, Sept.–Dec.	3 months
Foxglove — Sept.–Nov., Mar.–May	8–10 months
Goldenrod — Seeds, Jan.–Mar.	1 year
Goldenrod — Plants (division) — Nov.–Jan.	6 months
Gypsophila paniculata — Jan.–Mar.	4–6 months
Heliotrope — Apr.–May (boxes)	4–6 months
Hollyhock (biennial) — Sept.–Oct., Mar.–Apr.	12 months
Marguerite (see Chrysanthemum).	
Passion Flower — Sept.–Mar.	Rapid climber
Perennial Pea — Sept.–Mar.	4–6 months
Perennial Phlox — Sept.–Nov., Mar.–May	6–8 months
Perennial Poppies — Sept.–Nov., Mar.–May	6–8 months
Pinks, China — Mar.–Apr.	3 months
Salvia (Flowering Sage) — Feb.–Mar. (house), Apr.–May	6 months
Shasta Daisy (see Chrysanthemum).	
Smilax — Seeds, Jan.–Mar. (boxes)	8–10 months
Smilax — Tubers, any time	2–3 months
Snapdragon — Aug.–Oct., Mar.–Apr.	3 months
Sweet William — Aug.–Oct., Mar.–May	2 years
Tulips — Bulbs, Nov.–Jan.	Spring flowering

Violet — Seed, Sept.–Mar.	3–4 months
Violet — Plants, any time.	
Wallflower — Jan.–Mar.	6–8 months

Plants that will Thrive with Comparatively Little Water

VEGETABLES

Name — *Time to plant*	*How long to grow*
Corn (sweet) — Mar.–June, Sept.–Oct. (Give good cultivation)	2–3 months
Eggplant — Mar.–Apr. (boxes)	3 months
Eggplant — May–June (beds)	3 months
Melons — March to June after frosts	3–4 months
Peppers (chillies) — Jan. (boxes); Apr.	4 months
Pumpkin — March–June after frosts	5–6 months
Squash — March–June after frosts	5–6 months

FLOWERS

(All annual except those labeled otherwise)

Name — *Time to plant*	*How long to grow*
Alyssum, Sweet — Oct.–Dec.	2–3 months
Australian Pea Vine — Mar.–Apr.	3–4 months
Calendula "Pot Marigold" — Oct.–Apr.	2–3 months
Candytuft — Oct.–May	3–4 months
Castor Bean (P) — Mar.–June	3 months
Centaurea (Corn Flower) — Feb.–May, Aug.–Oct.	3 months
Collinsia — Sept.–Mar.	2–3 months
Eschscholtzia (California Poppy) — Sept.–Mar.	3 months
Feverfew (P) — Oct.–Dec.	6 months
Flax, Scarlet — Sept.–Oct., Feb.–May	3 months
Four-o'Clock — Sept.–Mar.	2–4 months
Gaillardia — Mar.–May	4 months
Geranium (P) — Seed, Sept.–Nov.	4–6 months
Geranium — Cuttings, any time.	
Gilia — Sept.–Nov.	3–4 months
Godetia — Oct.–Dec.	3 months
Lavender (P) — Cuttings, Nov.–Feb.	2 years

Flowers (*Continued*)

Name	*Time to grow*	*How long to grow*
Lippia repens (P), (Lawn plant)	Seeds, Oct.–Feb.	6 months
Lippia repens (P)	Plants (rooted cuttings), any time.	
Lupins (A & P)	Oct.–Dec.	3 months
Morning Glory (dwarf)	Feb.–Apr.	2–3 months
Nasturtium	Sept.–Apr.	2 months
Portulaca	Feb.–Apr.	2½ months
Petunia	Feb.–Apr. (after frost)	3 months
Sunflower	Any time	3 months
Pentstemon (P)	Oct.–Dec.	4–6 months
Plumbago (P)	Plants any time	Bush or climber
Salvia (Scarlet Sage)	Apr.–May; Sept. (boxes); Feb. (house)	4–6 months
Solanum jasminoides (P), (Potato Vine)	Plants, any time	10–20 feet
Verbena (mostly P)	Seeds, Oct.–Mar. (Dec.–Feb. in boxes); cuttings, Sept.–Mar.	4–5 months

APPENDIX C

Best Reference Books

Although some of the following works have been mentioned in the body of this book, it was thought best to indicate a few of the best books for the teacher's reference shelf. Unless otherwise indicated the publishers are The Macmillan Company.

Osterhout. — "Experiments with Plants."
Bailey. — "Manual of Gardening."
Bailey. — "Lessons with Plants."
Weed. — "Farm Friends and Farm Foes." D. C. Heath & Co.
Valentine. — "How to keep Hens for Profit."
Lyon. — "How to keep Bees for Profit."
King. — "The Soil."
Lipman. — "Bacteria in Relation to Country Life."
Stevens, Butler. — "A Practical Arithmetic." Scribners.
Hoag. — "Health and Index of Children." Whitaker-Ray-Wiggin Co.

APPENDIX D

Reference Lists of Bulletins and Circulars

(1) United States Department of Agriculture. Apply to Secretary of Agriculture, Washington, D.C., for List of Free Publications of the Department. Also ask to have your name placed upon the mailing list for the "Monthly List of Publications."

(2) Agricultural Experiment Station, Berkeley, California. Apply to the Director for the most recent bulletin. On the last page will be given a complete list of all available bulletins and circulars issued by the station.

BOOKS ON AGRICULTURE

On Selection of Land, etc.

Thomas F. Hunt's How to Choose a Farm	$1 75 net
E. W. Hilgard's Soils: Their Formation and Relation to Climate and Plant Growth	4 00 net
Isaac P. Roberts' The Farmstead	1 50 net

On Tillage, etc.

F. H. King's The Soil	1 50 net
Isaac P. Roberts' The Fertility of the Land	1 50 net
Elwood Mead's Irrigation Institutions	1 25 net
F. H. King's Irrigation and Drainage	1 50 net
William E. Smythe's The Conquest of Arid America	1 50 net
Edward B. Voorhees' Fertilizers	1 25 net
Edward B. Voorhees' Forage Crops	1 50 net
H. Snyder's Chemistry of Plant and Animal Life	1 25 net
H. Snyder's Soil and Fertilizers. Third edition	1 25 net
L. H. Bailey's Principles of Agriculture	1 25 net
W. C. Welborn's Elements of Agriculture, Southern and Western	75 net
J. F. Duggar's Agriculture for Southern Schools	75 net
G. F. Warren's Elements of Agriculture	1 10 net
T. L. Lyon and E. O. Fippen's The Principles of Soil Management	1 75 net
Hilgard & Osterhout's Agriculture for Schools on the Pacific Slope	1 00 net
J. A. Widtsoe's Dry Farming	1 50 net

On Garden-Making

L. H. Bailey's Manual of Gardening	2 00 net
L. H. Bailey's Vegetable-Gardening	1 50 net
L. H. Bailey's Horticulturist's Rule Book	75 net
L. H. Bailey's Forcing Book	1 25 net
A. French's Book of Vegetables	1 75 net

On Fruit-Growing, etc.

L. H. Bailey's Nursery Book	1 50 net
L. H. Bailey's Fruit-Growing	1 50 net
L. H. Bailey's The Pruning Book	1 50 net
F. W. Card's Bush Fruits	1 50 net
J. T. Bealby's Fruit Ranching in British Columbia	1 50 net

On the Care of Live Stock

D. E. Lyon's How to Keep Bees for Profit	1 50 net
Nelson S. Mayo's The Diseases of Animals	1 50 net
W. H. Jordan's The Feeding of Animals	1 50 net
I. P. Roberts' The Horse	1 25 net
George C. Watson's Farm Poultry	1 25 net
C. S. Valentine's How to Keep Hens for Profit	1 50 net
O. Kellner's The Scientific Feeding of Animals (trans.)	1 90 net
M. H. Reynolds' Veterinary Studies for Agricultural Students	1 75 net